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*Chemical
Engineering*

ELECTROCHEMICAL AND METALLURGICAL INDUSTRY

A Monthly Journal of Electrochemistry and Chemical
and Metallurgical Engineering

VOLUME VI

From January to December 1908

NEW YORK
ELECTROCHEMICAL PUBLISHING CO.

436831
3. 7. 45

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Entries from the Synopsis of Periodical Literature are indicated by S. (Synopsis); from the Analysis of Current Electrochemical United States Patents by A. (Analysis); from the Digest of Electrochemical United States Patents Prior to July, 1902, by D. (Digest); from Recent Metallurgical Patents by M. (Metallurgy). Illustrated articles are indicated by*.

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Electrochemical and Metallurgical Industry

VOL. VI.

NEW YORK, JANUARY, 1908.

NO. 1.

Electrochemical and Metallurgical Industry

With which is Incorporated Iron and Steel Magazine

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[Incorporated.]

239 WEST 39TH STREET, NEW YORK.

J. W. RICHARDS, PH. D.President
E. F. ROEBER, PH. D.Editor and Secretary
C. E. WHITTLESEY.Treasurer

Yearly subscription price for United States, Mexico and
United States dependencies, \$2.00; for all other countries, \$2.50
(European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post-Office at New
York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, JANUARY, 1908.

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Nineteen Hundred and Seven.

The business reaction which we, in common with other sober-minded critics, predicted last January in the days of 25-cent copper, has come. It has been blowing harder than was anticipated and larger. The causes for this are manifold and deep-seated. We were growing too fast, and as the Germans say, "a tree never grows quite to heaven." The volume of business increased steadily every year from 1904 to 1907. Every agency of production was overloaded. There is a point of maximum efficiency for any machine, and if it is speeded or loaded beyond this point the slight increase of production is accompanied by a great increase in the bill for fuel or repairs. It was so with our great industrial machine in the early months of 1907. Especially with the railroads, which were "overloaded" so much that their efficiency decreased. Then there was too rapid an increase of prices. Wages rose to beyond the point where labor was profitable to the employer at such prices for his product as the world could continue to pay. In addition to this, labor became in all industries, notably the mining and smelting industries of the West, indifferent and inefficient. A lack of trustworthy reliable men became evident. The quality of the immigrants from Southern Europe was inferior to those we had already received, and their ignorance of the English language made it difficult to turn them into reliable producers. At the same time, we were living at too expensive a rate, putting too large a proportion of our national income into automobiles and other non-productive outgoes. Large capital obligations were also incurred for meritorious enterprises, the return from which, though sure to come, was necessarily deferred for several years. An instance of this is the expenditure of \$15,000,000 in the copper mines of Ely, Nev., which will make no returns for several years after the first expenditure.

* * *

This increase of gross expenditure and diminution of net earnings and this commitment to large expenditures with deferred return—as the Gary plant of the Steel Corporation and the "St. Paul" extension—necessitated an expansion of credit and a borrowing from the future of sums which the future could well take care of, but which were not available in the present. The "entrepreneur" class owed too much, and when creditors began to call in loans and collateral must be sold, the offerings of securities were soon larger than the demand and a tremendous shrinkage in prices resulted at once. This narrowed the basis of credit, and it soon became impossible to float new enterprises and difficult to keep those already launched above water, for all enterprises until they have accumulated a great surplus, like Calumet and Hecla or the Standard Oil, must borrow money for development and extensions. This condition prevailed throughout the entire world, especially in Germany. At the very time this restriction became necessary, there existed a wide-spread, underlying feeling of

uneasiness even among sober-minded men. The discussion of socialistic doctrines in this country and Europe made many ask themselves, "Is our distribution of prosperity entirely just? May we not be on the verge of important changes in our ownership systems not what the extremists demand, but something unforeseen but none the less radical?" The coincidence of a vague feeling of uncertainty and a contraction of credit after a period of expenditure resulted in a general loss of confidence. This was no doubt aggravated by the remembrance of the shocking disclosure of ignorance and selfish greed among the trustees of insurance funds in New York. Possibly some alarm was caused by the explosiveness of the President. Doubtless this was to a certain extent a contributing cause, and so was the great loss at San Francisco, but the underlying causes were, as first indicated, that we spent more than we earned for three or four years, and tried to do too much before we had saved the money to do it.

* * *

When stringency began, the lack of confidence in our trust companies and banks was intensified in its growth by the general feeling of uneasiness referred to, though it might well be that those who felt most profoundly that socialistic agitation meant something portentous were not at all the ones to yield to the monetary panic. A panic or a sense of alarm pervading a crowd is something the sociologists are unable to explain. The danger may be entirely imaginary. The crowd may be composed of individuals who have never seen one another. They may perhaps receive a common suggestion from the press or from some absurd rumors. They seem to communicate by sympathy. At all events the crowd appears and is entirely immeasurable. This condition of mind rarely lasts more than a short time, but while it lasts men are not themselves and may do incalculable damage. Society in a panic may be compared to an engine when the governor belt has broken and the engineer is afraid to shut the throttle. We have been perilously near such a condition for some weeks, but the emotional stress has evidently weakened. Now we must retrench, save and invert. The period of depression is the fruitful period to a nation. It is then that it grows rich. So rapid is our production that we need only to stop our sources of waste for three months and our surplus capital will clamor for outlet.

* * *

Strange as it may sound, we are after all in good financial condition to-day, that is in essentials. The production per capita of food products and metals was never so great before. Our expenditures in irrigation and other new enterprises are about to yield enormous returns. Our West is in sound condition, quite the reverse of 1893. If San Francisco is really relieved from the control of criminals and spoilers the fire loss is made up. We have the men and, above all, we are acquiring the science and experience needed in industry. In this alone we are many millions richer in power than we were ten years ago. The man who "goes short" on American prosperity because of a temporary setback will be a loser. It is risky to sell short an article that is practically inexhaustible. One can corner a thing only when the supply is limited. From this viewpoint, which appears the only logical one, we extend to all our friends our wishes for a prosperous year 1908.

The Status of Electrochemical Industries.

Probably the two most interesting electrochemical novelties of the past year were Mr. Acheson's colloidal ("deflocculated") graphite and Dr. Potter's silicon monoxide ("monox"). These two examples show clearly the possibilities and the difficulties which are before the electrochemical inventor—the possibilities of entering new and unexpected industrial fields and the difficulty of having to determine first in long research all the properties of a new material and then to find a market for it. While we, therefore, see the electrochemical industries grow and cover fields undreamed of ten years ago, it is clear that this growth to be sound must be slow and gradual. While the electrochemical inventor's work in the laboratory may be revolutionary, it can be transformed into commercial results only by slow evolution, following strictly the rules of logics. The evolution of the electrochemical industries along such logical lines is indeed the most characteristic feature of the development of the past year. Thus, in the iron and steel industry the manufacture of ferro-alloys has been steadily growing with the extension of the high-speed tool-steel production; besides continued imports of large quantities of ferro-alloys from Europe we have now a strong and rapidly yet quietly extending home industry. The use of the electric furnace for making high-grade steel also progresses steadily, especially in Europe, and it is characteristic that more attention is now being paid to the metallurgical side of the problem. The two articles of Prof. Wedding and Mr. Thallner in this issue are interesting indications of this fact. The electric furnace is no longer considered simply as a melting furnace, but the attention is now directed to the possibility of using special slags fluid at the high temperatures available and permitting a very complete purification of the metal. In the new year we will also witness the final completion of the Héroult electric pig iron plant of the Noble Electric Steel Co. in California, which is not less interesting because we have to do here with singularly special local conditions.

* * *

In the fixation of atmospheric nitrogen by means of electric discharges, the moving-arc method, instead of the old spark method, seems now to be universally preferred, and the problem appears to be solved in its chief technical features, but we have often pointed out that the commercial success of the Birkeland-Eyde process in Norway is essentially based on exceedingly low power prices. All the "old" electric furnace industries in this country have been flourishing during the past year and new companies are springing up. In the sodium-chloride electrolysis industry the fire of the Acker Process Co. works has removed the only process using a fused electrolyte from the field. The industry extends quietly wider and wider into the paper and pulp mill field and a kind of diaphragm cell (in the widest sense) seems to be generally preferred. The large copper refineries near New York have completed important extensions during the past year. It will be interesting to watch developments in the aluminium industry in view of the Bradley patent's expiration in 1909. The present sole producer certainly occupies now a formidable commercial position. Taken in the whole, the electrochemical industries have shown a sound, steady growth, which offers the brightest prospects for the future.

The Iron and Steel Industry in 1907.

Nothing could show a greater antithesis than a comparison of iron trade conditions at the beginning and at the close of the year 1907. The year opened with a strong demand for all classes of iron and steel, production being forced to the utmost, new blast furnaces and steel plants being rushed to completion, pig iron prices advancing and finished steel prices being held on the previous basis only by the conservatism of producers. The year closes with production at about one-third the maximum rate, demand extremely light, work suspended or being but leisurely prosecuted on new plant, pig iron prices down, and prices of finished steel products maintained only by the knowledge of producers that cutting would induce demoralization on account of the lack of consuming demand. The change in productive activity began in the closing days of October; until then there had been an almost steady increase in production, with the result that the October output of pig iron was the largest for any month in the history of the American iron trade. Then came, in but little over two months, a reduction in output of between 60 and 70 per cent. For a period of almost three years, or since the beginning of 1905, the productive resources of the country had been continuously strained, the steadily increasing output during this period being due to the completion of new furnaces and the harder driving of old furnaces. At all times Bessemer and open-hearth steel making capacity has been ample to refine the pig iron available, and there has easily been sufficient rolling capacity to take care of the ingot output, so that production of finished steel has been gaged by the supply of pig iron.

* * *

The decline in demand and production, beginning late in October, was simultaneous with a financial panic which has been unique in its suddenness and scope. The financial panic did not cause the slump in the iron and steel trade. It did slightly accentuate it, but had financial conditions remained easy there is absolutely no question that a general slowing down in the iron and steel industry would have occurred before the close of the year. All the developments of the preceding ten months had pointed clearly to such a slowing down. These evidences had arisen, in a comparatively small degree, through a tightness in the money market which was visible a year ago; but that was not a cause, since money is merely a medium and reflects conditions which are more fundamental. Encouraged by the guarantee of steady prices brought about by the formation and wise management of the United States Steel Corporation, railroads and other consumers were led to buy freely and anticipate requirements. Such a policy could not be pursued indefinitely, as there is a limit to the anticipation of requirements, no matter how free from trouble the future may appear to be. It was purely an incident, that these heavy industrial operations caused a tightness of money; they were bound to slack off in any event, and had it been that industry was being conducted without the use of money or credit the tapering off would, nevertheless, have been inevitable. In our iron and steel market review last March this necessity was clearly outlined, the situation being gone over in detail, and the outlook summed up in the words: "The indications thus are, that while the greatest activity

should prevail for six or nine months to come, there will be some recession in demand late this year and in 1908." The program was carried out exactly, except that the financial panic precipitated almost the entire recession in demand upon the two closing months of the year. The "greatest activity" which was referred to prevailed for exactly six months from March 1.

* * *

That same review last March contained a full presentation of the increase in pig iron capacity and, as already noted, this is an index to the whole industry, since finishing capacity has always been ample. It had taxed the capacity in 1902 to make 17,821,307 gross tons of pig iron; in 1906 a similar taxing of the increased capacity resulted in an output of 25,307,191 tons. Then, referring to the calendar year 1907, it was said: "Through the progress of new erection it can be estimated, on quite complete data, that so far as physical considerations control, a production of 28,000,000 tons can be made. With the present trade outlook it is quite certain that no such tonnage can be absorbed, and a reaction in prices of pig iron is inevitable." A few figures will present a clear picture of what has occurred, these referring to gross tons of pig iron:

Production in 1906 ⁶ in tons.....	25,307,191
Rate during first ten months, 1907.....	27,350,000
Rate during October.....	28,000,000
Estimated output, 1907.....	25,750,000
Approximate rate close of year.....	10,000,000
Capacity of furnaces completed in 1907....	2,110,000
Capacity under construction, Jan. 1, 1908..	3,500,000

* * *

There have been scarcely any changes in prices of finished steel products during the year. Pig iron advanced until about June 1; thereafter there was a continued recession, at first only by the reduction of premiums for prompt iron, and afterwards by a general decline. The course of pig iron prices is illustrated by the ascertained average selling price of Bessemer pig iron each month, this average being compiled for the adjustment of certain contracts from actual sales. These disclose the prices at which pig iron was sold better than do current market quotations. It may be noted that foundry pig advanced to a somewhat higher level than Bessemer, and declined towards the close of the year to a lower level. The Bessemer average, f. o. b. valley furnace, has been as follows: January, \$22.07; February, \$21.93; March, \$22.05; April, \$21.36; May, \$23.28; June, \$23.25; July, \$22.47; August, \$22.00; September, \$22.00; October, \$21.89; November, \$19.75; December, \$19.00. In November, consumers notified mills to discontinue shipments on nearly all the contracts on books, except in cases where erection work could not conveniently be stopped; since then the curtailment in output has continued, there being scarcely any new business placed. The manufacturers have had frequent conferences, and have appointed a number of committees to canvass the situation, prevent demoralization in prices, and induce as great a curtailment in production as the state of trade calls for. Their efforts have thus far been successful, and what in the old alignment of the iron and steel trade would have produced a demoralized rout has resulted in nothing but an entirely orderly, although rapid, retreat, with the band playing the most stirring music.

Fluctuations of Metal Prices in 1907.

On page 40 of this issue we give some curves showing the fluctuations of the prices of metals during 1907. The curves show at a glance the development of the metal market during the past twelve months.

The iron curve refers to foundry iron No. 2 as most representative for the iron market, and is based on the *Iron Age* quotations for foundry No. 2, standard, Philadelphia. The ordinates represent dollars per gross ton.

All the other curves are based on the quotations of the *Engineering and Mining Journal*. The curve for electrolytic copper relates to New York quotations for electrolytic copper in cakes, ingots or wire bars.

The zinc curve is based on New York quotations for spelter, ordinary Western brands.

The lead curve is based up to the middle of November on the quotations of the American Smelting & Refining Co. for nearby shipments of desilverized lead in 50-ton lots or larger. At the middle of November the American Smelting & Refining Co. announced that it withdrew its official quotations and would compete in future in the open market. The end of the curve therefore is based on open market quotations.

The Iron and Steel Market.

The curtailment in iron and steel production, begun on such an enormous scale about Nov. 1, has been continued through December, and the year closes with a rate probably in the neighborhood of one-third the October rate. Actual production in the closing week of the year was probably well under the rate of one-third, but in a general statement of this sort regard must be had to the fact that at the holiday season there is always some closing, irrespective of market conditions.

It is difficult to find expressions adequate to describing the stagnation which has fallen upon the trade. There has been practically no business at all placed during December, and the relatively small proportion of orders upon which shipments were being made at the beginning of the month have been playing out, so that for the beginning of January there is scarcely any tonnage to be shipped.

It is usual to ascribe this sudden stoppage to financial conditions. Doubtless this has been a contributory cause, but the fundamental trouble has been more deep seated. Conditions have been shaping themselves for a long time for a period of recession in demand if not in prices. Demand had increased as productive capacity continued to increase until it could no longer keep pace, and the departure of these lines from each other has always been the signal in the American iron trade for a serious disturbance. It is rather an incident than a cause that the departure occurred at a time of financial panic.

The month of December has been taken up very largely with meetings and conferences of various interests, designed to prevent a demoralization in prices consequent upon an effort to induce business when there was no business to be had. It would be of no advantage to any of the interests involved for prices to be slaughtered at a time like this, and it is most fortunate that producers have been able, by a free interchange of thought, to prevent demoralization. There have been no serious declines in prices, and the time is approaching when by an orderly and dignified readjustment, where such may be actually required, the foundation can be laid for a resumption of buying.

The low point in production is undoubtedly reached at the first of the year, and whatever change now comes must be in the direction of an improvement. Even the more optimistic do not expect that improvement to be rapid. The large buyers, as a rule, must finance their purchases, and that may be difficult for a time. The general expectation is that buying will first be by the smaller interests whose trade is steady although the

individual orders are not large. Demand for tin plate, for instance, is improving, and full activity for the tin mills is promised within a very short time. The canning crops will not wait, and preparation must now be commenced for them.

An interesting feature of the readjustment in progress is that it appears likely to be accomplished without any general reduction in wages, such as was at the beginning of December regarded as well nigh inevitable. The United States Steel Corporation took the lead in this, as it does in most iron and steel matters, and about the middle of December decided that it would not reduce wages. The independents, outside of some concerns in the East, have been following the lead pretty generally. With no wage reductions, the expectations of buyers of lower prices undergo a material discount and confidence is enhanced.

PIG IRON.

A great many merchant furnaces blew out during December, and others are scheduled to go out the first week or fortnight in January. With a further curtailment in pig iron output by the steel interests, it seems that the rate of pig iron production in the country as a whole has either dropped below the 10,000,000-ton market before Jan. 1, or will pass below that mark in the first fortnight of the new year. During nearly the whole of October the rate was about 28,000,000 tons, the record in the history of the American iron trade. Pig iron has declined during December, but not enough business is being done at the close of the month to establish genuine market quotations in all cases. Southern pig iron has clearly declined to \$13. Birmingham, and it is possible that this price could be shaded. Bessemer iron is purely nominal at \$19, valley, the same figure quoted last month, but if there were important business in sight it is possible \$18 or lower could be done. Basic pig is \$17 to \$17.50, valley. Foundry iron has been available at \$16.50, or \$17, at most central Western furnaces.

STEEL.

The United States Steel Corporation has sold about 100,000 tons of sheet bars, for first half delivery, to the South Wales tin plate mills and sheet mills in Wales and the Midlands. The price realized is, of course, much below the domestic market, but it is regarded as advantageous to have the tonnage. Billet prices remain, by an informal understanding of the mills, at \$28, Pittsburg, for either Bessemer or open-hearth, but under the lead of the Carnegie Steel Co. sheet bars have been reduced from \$31 to \$29, Pittsburg. There has been practically no business done in the domestic market, but there seems to be no disposition on the part of producers to shade the recognized market prices.

FINISHED MATERIAL.

Deliveries are pretty well over to the steel car interests on the large mass of car orders on which they worked all year, nearly all this car business being cleared up, with no fresh business immediately in sight. Some structural business is being placed from time to time, and deliveries have been maintained on many jobs where the work was partly under way. There has been an improvement in tin plates, and mills are resuming. In sheets, business is rather light, but what there is calls for immediate delivery. Some mills are shading plates by \$2 a ton, but this does not cover the full range of widths and thicknesses. Sheets are being shaded more or less generally by \$1 to \$2 a ton. In wire products the market level is that which prevailed before the official advance of \$1 a ton on Sept. 3. Otherwise prices are as given below, these being the recognized quotations; some of these may be reduced slightly after the first of the year:

Structural shapes, \$1.70 per hundred pounds for beams and channels, 15 inches and under.

Plates, \$1.70 for tank quality.

Merchant steel bars, \$1.60, base, half extras.

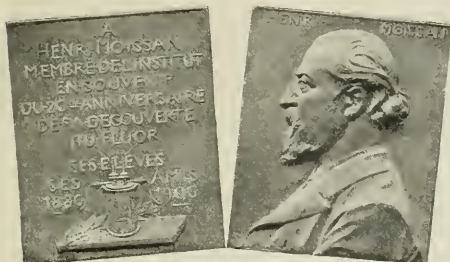
Sheets, 28 gage, \$2.60 for black and \$3.75 for galvanized

Tin plates, \$3.90 for 100-pound cokes,

Plain wire, \$1.90.

The Moissan Medal.

Shortly before Prof. Henri Moissan's lamentable death last year, the phenomenal importance of his life work was twice recognized, first by the bestowal of the Nobel prize, and, secondly, by his old students and scientific friends by a presenta-

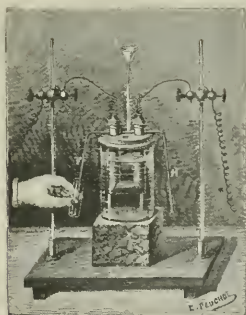


IMPRINTS ON MOISSAN MEDAL.

tion of a medal to commemorate the twentieth anniversary of his work on fluorine.

A replica of this medal has just been sent to all subscribers, together with a beautifully illustrated account of the proceedings at the presentation of the medal to Prof. Moissan. The pictures are herewith reproduced.

The medal is a fine specimen of the engraver's art of M.



*L'expérience qui a permis de
isoler le fluor a été faite
pour la première fois le 26
juin 1886*
Henri Moissan

MOISSAN'S APPARATUS FOR THE ISOLATION OF FLUORINE.

Chaplain. The act of presentation was quite informal, only the Paris members of the committee being present. Two short addresses were made, one by Prof. Lebeau, who spoke for the students and friends of Moissan, the other by Dr. Chabrie, who represented the (Paris) Institute of Applied Chemistry. While the isolation of fluorine was the chief object of their remarks, the speakers naturally referred also to Moissan's high-temperature work with the electric furnace.

Prof. Moissan replied in a few words expressing his ap-

preciation of this kind remembrance of his scientific friends and old students.

By far most of the subscribers were, naturally, Frenchmen, though we also find a series of illustrious names from other countries. Among the subscribers from England were Lord



THE LATE HENRY MOISSAN.

Kelvin, Lord Rayleigh, Sir William Crookes, James Dewar and R. S. Hutton; from Germany, Hans Goldschmidt, Walter Nernst, J. H. van't Hoff, Emil Fischer, Boettinger and Landolt; from Switzerland, G. Lunge; from Denmark, Julius Thomsen. The only four American subscribers were C. A. Doremus, Ira Remsen, G. F. Kunz and F. Lengfeld.

The Perkin Medal.

The Perkin medal, which is to be awarded annually to a distinguished chemist residing in the United States, will be awarded for the first time this year. The official presentation of the medal will be made at the January meeting of the Society of Chemical Industry. While it is this society which has founded the medal, all other national chemical societies were represented in the committee which made the award at its meeting held at the Chemists' Club on Dec. 16. The committee voted unanimously to confer on Mr. J. B. Francis Herreshoff the honor of being the first Perkin medalist.

Mr. Herreshoff is one of the most prominent and successful chemical engineers. His connection with the General Chemical Co. and the Nichols Copper Co. enabled him to do highly important engineering work on many fields of chemical and metallurgical industries, as in electrolytic refining of copper and in the development of the contact process for making sulphuric acid. Of the many apparatus which he has devised the Herreshoff roasting furnace is probably best known to the general engineering public.

Lord Kelvin.

By Lord Kelvin's death the world has lost the most brilliant representative of the Victorian era in England, and one of the greatest scientists and engineers of all times and all countries.

He was both a scientist and an engineer, and the most notable general mission which he fulfilled was the introduction of science, exact mathematical science, into engineering.

William Thomson, born in 1824, was the son of James Thomson, professor of mathematics in Glasgow, early distinguished himself in applied mathematics, and at the age of only 22 years he was appointed to the chair of natural philosophy in Glasgow. When the first Atlantic cable was proposed he applied his mathematical skill to the solution of the engineering problems involved and was immensely successful. Queen Victoria knighted Thomson in 1886, and made him Lord Kelvin in 1892. There is no necessity to summarize here the immense work of his life; he was equally successful in his contributions to the mathematical theory of all branches of physics as in the design of a long series of instruments and apparatus, especially electromagnetic measuring instruments.

Lord Kelvin was buried in Westminster Abbey on Dec. 23 in a grave at the foot of Sir Isaac Newton's monument, and close to the spot where about a quarter of a century ago Darwin was laid to rest. The inscription on the coffin reads as follows: "William Thomson, Baron Kelvin, of Largs, P. C., O. M., G. C. V. O., F. R. S., LL. D., D. C. L. Born June 26, 1824. Died Dec. 17, 1907."

CORRESPONDENCE

Detinning.

To Editor of the Electrochemical and Metallurgical Industry:

SIR:—I have just noted the letter of C. Offerhaus in your September number, 1907, concerning the detinning of scrap with dry chlorine gas.

It may be of interest to know that the writer saw this process in successful operation at the chemical works of W. H. Bower, Philadelphia, Pa., in the spring of 1898. Therefore, this process has not only been in use in Europe for a long time but also in this country for at least ten years.

WEST VIRGINIA UNIVERSITY.

F. L. KORTRIGHT

The First Electrolytic Chlorate Plant.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—In your November issue, page 440, you mentioned in a note on the cost of water-power, the plant of Vallorbe (Switzerland). As the former general manager at Vallorbe, I give the following particulars which may also be of interest:

The height of the fall is now about 78 meters, for a new hydraulic installation has been made which adds 8 meters. The power utilized is about 3,000 hp., or 2,200 electrical horsepower for electrolysis. The annual charges per horsepower are about \$7.00.

The output was in the beginning (1892) about 600 tons of chlorate of potash, then (1899) about 1,200 tons, now 1,800 tons and could be easily increased to 2,200 tons, to the round figure of 1 ton per electrical horsepower-year. The cost of production (at the plant) for chlorate of potash packed in kegs was at first \$5.00 for 100 pounds, and is now about \$3.00. If interest, depreciation, etc., are included the cost is about \$4.00.

Under these circumstances the chlorate industry is very attractive and lucrative. The plant of Vallorbe was the first electrolytic chlorate works. Since its establishment in the nineties the works have been enlarged and the process has been improved in so many respects that it is now absolutely different from the original process.

The important conditions for successful manufacture are: First, the electrochemical process must give a good ampere-hour efficiency. Second, the electrolytic apparatus should be so

designed as to make the voltage and the cost of maintenance a minimum.

About three-fourths of the chlorate of potash produced at the plant of Vallorbe is sold in Russia, Japan, South Africa and foreign countries.

The principal consumers are the match and fireworks and explosive industries.

M. COLLEU.

PARIS, FRANCE.

The Use of the Electric Furnace for Making Alloy Steels.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—The Héroult electric steel furnace has been sufficiently discussed in general, and it is hardly necessary to add anything to the statement that plants are now in operation and under construction capable of producing a hundred thousand tons or more of special grades of steel annually.

In view of the great progress, however, which is now being made in alloy steels it will probably be of interest to steel makers to know that remarkable results have been obtained lately in Europe in the production of alloy steels in the Héroult furnace. It is easy to see why the Héroult furnace is specially suitable for this purpose.

Metallurgists and experienced steel makers know that there is a considerable loss of ferro-alloys in oxidizing furnaces, due to the oxidation of the added element, and that the resulting oxides form solid particles and remain more or less distributed in the steel. A uniform metal cannot be obtained therefore, nor is the added element evenly and uniformly alloyed with the steel.

On the other hand, in the electric furnace of Héroult the metal bath is absolutely protected from the atmosphere, so that no reoxidation is possible. Further, there is a continuous and rapid circulation in the metal bath, and there being no danger from oxidation or loss, the liquid steel may remain in the electric furnace at any desired temperature for any length of time. The uniform distribution and thorough amalgamation of any addition, either in the form of ferros or otherwise, is thus readily obtained without any special or extra care, and with the greatest possible economy. In the case of alloy steels, as well as any other grades of steel made in the Héroult furnace, the finished product is always thoroughly homogeneous and absolutely free from oxide gases or slag.

If further progress is to be made in the production of alloy steels on an economical and commercial basis, the important question is to find the most suitable furnace that will do the business most economically on a large commercial scale, either in conjunction with oxidizing furnaces operating as a purifier and a non-oxidizing finishing furnace, or where large daily products of tonnage steel are concerned, in the form of a large steel mixer, as an adjunct to a battery of oxidizing furnaces.

The purifying and finishing process requires comparatively little time and little expense over the cost of the roughing down process in oxidizing furnaces, and Dr. Héroult states that for steel mixers, where less power is required for purifying purposes, the cost is almost compensated by the savings in the required quantity of ferro-alloys and other economies.

The Héroult electric furnace and process has ceased to be an experiment, and there is no doubt in my mind that it is the most ready means of solving the all-absorbing problem in the steel industry: how to improve the quality of the present product, in a way that is economical and commercially feasible. It is the only furnace that combines all the advantages of the air-tight crucible and all steel making oxidizing furnaces, without any of the disadvantages of either. It is absolutely protected from the atmosphere, like the crucible, and can handle large units of metal and subject same to metallurgical operations as freely and as easily as is being done to-day in any oxidizing furnaces known to me.

R. H. WOLFF.

NEW YORK CITY.

The Duplex Process for Steel Making.

BY PROF. HENRY M. HOWE.

If we are asked to state concisely the advantage of the duplex process which is to compensate for its disadvantage of complexity, must we not say that it is this in the last analysis; that it simplifies the conditions with which the composition of the pig iron has to comply, and thus lessens the danger of making "unsift" iron; i. e., that which is unsuited in composition to the process for which it was intended, and therefore presents us with the dilemma of either (1) using it in that process, though at a disadvantage, or else (2) using it in some other process or selling it; in either case only too often at a loss which may be serious, and of lacking the iron needed for the process which we wish to use.

The duplex process, in its most promising form, removes the silicon and part of the carbon of the pig iron in an acid Bessemer converter, and then removes the phosphorus and brings the steel accurately to the desired composition and temperature in a basic open hearth furnace to which the molten metal is transferred from the converter. How does this simplify the conditions with which the composition of the pig iron must comply? Pig iron for the acid Bessemer process must needs be low in sulphur, and its silicon content should be nearly constant, while that for the basic open hearth process should be as nearly as possible free from both silicon and sulphur. But these limitations are very difficult to comply with, because most of the conditions in the blast furnace which tend to restrict the sulphur-content tend to raise the silicon content. It is by relieving the blast furnace manager of these limitations that the duplex process may be of service.

The reason why the sulphur content of the pig iron for the acid Bessemer process should be small is that this process removes none of this most harmful impurity. The reason why the silicon-content should be nearly constant is, first, that it is essential to the making of sound steel of good quality that the temperature at which the process ends and at which the molten steel is cast should be exactly that aimed at; and, second, that variations in the silicon-content tend strongly to cause corresponding variations in the temperature of the process, for the very simple reason that here the combustion of silicon is the chief source of heat. It is true that the variations in silicon are greatly lessened by the use of the "mixer," and that the means of counteracting them are convenient and pretty effective. But, though the harm which they do is thus greatly lessened, it is not wholly done away with. But if, as in the duplex process, the Bessemer converter is relieved of the work of bringing the steel to the needed casting temperature, and has only to remove the bulk of the silicon and carbon without reference to the temperature, then the silicon content of the pig iron becomes relatively unimportant as regards the Bessemer end of the process.

The reason why the silicon-content should be small in pig iron for the basic open-hearth process is that the silica which results from the oxidation of the silicon not only corrodes the basic lining of the furnace, but also, by lessening the basicity of the slag, interferes with the removal of both phosphorus and sulphur, a most serious harm. The reason why the sulphur-content should be small is that the work of removing sulphur is both slow and costly. But if the silicon of the pig iron is removed by a preliminary treatment in a Bessemer converter, then the silicon-content of the pig iron as it issues from the blast furnace is a matter of indifference as regards the open-hearth end of the process, and we have already seen that it becomes of only minor importance for the Bessemer end.

With the silicon-content of the pig iron thus made rela-

tively unimportant, the work of desulphurizing in the blast furnace becomes at once easier and more thorough, because it is freed from the hampering need of simultaneously controlling the silicon-content.

If we look at the matter only from the point of view of the open-hearth process, the preliminary desilicidizing in the Bessemer converter may prove profitable; but whether it will prove more profitable than desilicidizing in a regeneratively heated mixer remains to be proved.

We naturally conjecture that, if there is but a moderate tendency to excessive silicon-content, then the mixer treatment should be the more profitable, because it would probably imply less loss of iron than the preliminary Bessemerizing. On the other hand, if the silicon-content is likely to be very excessive, then the Bessemerizing should be the better, because it should remove such a large excess of silicon more surely and easily than the mixer.

COLUMBIA UNIVERSITY, New York.

The Centennial of the Discovery of Sodium and Potassium.

On Nov. 19, 1807, Sir Humphry Davy, then 29 years old, delivered before the Royal Society, in London, a Bakerian lecture entitled "Some new phenomena of chemical changes produced by electricity, particularly the decomposition of the fixed alkalies, and the exhibition of the new substances which constitute their bases and on the general nature of alkaline bodies." The results described in this lecture had been obtained by Davy with the aid of the voltaic pile, discovered by Volta in 1800.



SIR HUMPHRY DAVY.

Davy first experimented with aqueous solutions of alkalies, but obtained, of course, on electrolysis only oxygen and hydrogen. On the supposition that the water interfered, he heated a platinum spoon, filled with potash, by directing a stream of oxygen on the flame of an alcohol lamp. The potash was thereby brought to red heat and was rendered perfectly fluid. The spoon was connected with the positive pole of a 100-plate voltaic pile, while a piece of wire, dipping into the potash, was the negative pole. There was "a most intense light" exhibited at the negative pole, and when the poles were changed this light always appeared at the negative pole. Davy concluded that a very inflammable substance was formed from the potash at the negative pole, but that its isolation did not succeed on account of his method of heating.

When, however, by using a sufficiently strong voltaic pile he succeeded in employing the electric current for both heating and electrolyzing potash (slightly moistened by exposure to air), "small globules having a high metallic lustre, and being precisely similar in visible character to quicksilver appeared." By cooling, a protective coating of potash formed around the potassium. Analogous experiments led to the isolation of sodium. With the small quantities of the metals thus produced Davy was able to determine their properties. The accompanying picture of Sir Humphry Davy is reproduced from our London contemporary *Electrical Engineering*.

Now some eighty years later these processes were reduced to operation on a large scale by an American, Hamilton Young Castner, is recorded on page 121 of our Vol. I. We do not belittle Castner's magnificent and persistent work, by emphasizing the importance of Sir Humphry Davy's ingenious pioneer research, which has placed him forever in the front rank of chemical experimenters of all times. The Faraday Society rightly celebrated the centenary of Sir Humphry Davy's discovery in its meeting of Dec. 17 by an illustrated lecture of Dr. F. Mollwo Perkin.

Metallurgical Calculations.

By J. W. RICHARDS.

Professor of Metallurgy in Lehigh University.

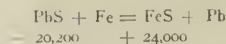
The Metallurgy of Lead.—I.

The extracting of lead from its ores and the refining of the crude metal to commercial lead, constitutes the metallurgy of lead. The chief ore is Galena, lead sulphide, PbS ; but the carbonate, Cerussite, $PbCO_3$, and the sulphate, Anglesite, $PbSO_4$, occur at some places in important quantities; the silicate, phosphate, molybdate, tungstate, chloride and native lead are rare minerals.

The reduction of the oxidized lead ores, such as often occur at the outcrops of sulphide veins, is very simple; carbon, the cheapest and most universal reducing agent, reduces them satisfactorily at a red heat, with some loss of lead by volatilization. The sulphide of lead, however, is not reducible by carbon; it requires other treatment. If we tabulate the most common sulphides according to their thermo-chemical heats of formation, expressed per unit weight of sulphur held in combination (32 kilograms), we find the common metals arranged as follows:

	Calories.
Potassium (K_2S).....	103,500
Calcium (Ca_2S).....	94,300
Sodium (Na_2S).....	89,300
Manganese (Mn_2S).....	45,600
Zinc (Zn_2S).....	43,000
Cadmium (Cd_2S).....	34,400
Iron (Fe_2S).....	24,000
Cobalt (Co_2S).....	21,900
Copper (Cu_2S).....	20,300
Lead (Pb_2S).....	20,200
Nickel (Ni_2S).....	19,500
Mercury (Hg_2S).....	10,600
Hydrogen (H_2S).....	4,800
Silver (Ag_2S).....	3,000

A glance at this table shows us that some metals unite with sulphur more energetically than lead does, and others less energetically, and points to the theoretical possibility of decomposing lead sulphide by the agency of copper, cobalt, iron, cadmium, zinc, etc. Of these agents, iron is, of course, the cheapest and most available, and can be used to reduce lead sulphide with formation of iron sulphide.



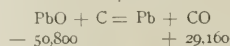
Showing an excess heat development, per 207 parts of lead set free, of $24,000 - 20,200 = 3,800$ Calories. If lead sulphide and iron are brought together at a red heat, at which heat the sulphide is molten, they react energetically with evolution of heat—enough theoretically to raise the temperature of the 207 kg. of lead and 88 kg. of iron sulphide some $280^\circ C$. The reaction is fairly complete if sufficient reducing agent is present and time is allowed, so that it can be used in assaying to determine lead by fire assay, but in commercial practice more or less undecomposed lead sulphide always remains in the iron sulphide, forming a sort of double sulphide or iron-lead matte.

It is interesting to note, *en passant*, that lead vigorously reduces silver sulphide, the liberated silver alloying with the excess of lead. This reaction is accompanied by a large evolution of heat, as the table shows, is the basis of the ordinary assaying methods for silver ores, and is used commercially to extract silver from its ores wherever lead is plentiful.

The affinity of lead for oxygen is a no less interesting subject, since it concerns not only the reduction of oxide ores but also the roasting of sulphide ores to oxide, and very largely controls the refining of impurities from lead by methods involving oxidation. The heat of combination of some of the more common elements with oxygen, expressed per unit weight of 16 kilograms of oxygen held in combination, is as follows:

	Calories.
Magnesium (Mg, O).....	143,400
Calcium (Ca, O).....	131,500
Aluminium $1/3(Al, O^2)$	130,870
Sodium (Na^2, O).....	100,900
Silicon $1/2(Si, O^2)$	98,000
Manganese (Mn, O).....	90,900
Zinc (Zn, O).....	84,800
Tin $1/2(Sn, O^2)$	70,650
Iron (Fe, O).....	65,700
Iron $1/3(Fe^2, O^2)$	65,200
Nickel (Ni, O).....	61,500
Hydrogen (H^2, O).....	58,060
Antimony $1/3(Sb^2, O^2)$	55,630
Arsenic $1/3(As^2, O^2)$	52,130
Lead (Pb, O).....	50,800
Carbon $1/2(C, O^2)$	48,600
Bismuth $1/3(Bi^2, O^2)$	46,400
Copper (Cu^2, O).....	43,800
Sulphur $1/2(S, O^2)$	34,630
Sulphur $1/3(S, O^2)$	30,630
Carbon (C, O).....	29,160
Mercury (Hg, O).....	21,500
Silver (Ag^2, O).....	7,000

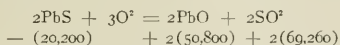
Reduction of Lead Oxide.—An inspection of above table shows that lead oxide is a weak oxide, weaker than the oxides of most of the common metals. It is reduced to metallic lead by many reagents with evolution of heat. It is also reduced by some weaker reagents with absorption of heat, provided that the oxide formed is gaseous and the necessary heat energy is supplied from outside. For instance,



involves an absorption of 21,640 Calories, or several times as much heat as is necessary to raise the reacting substances, PbO and C , to the reacting temperature, a red heat. The reaction is endothermic, absorbing heat, and therefore only progresses in measure as the necessary calories are supplied from outside. The fact that all the substances concerned are liquid or solid except the product CO , gives a predisposing cause which facilitates the reaction, that is, the reaction can

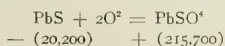
only go one way, since the CO gas escapes from the sphere of action as soon as formed.

Oxidation of Lead Sulphide.—When PbS is roasted, that is, heated to redness with free access of air, both the sulphur and the lead tend to oxidize, generating a large heat of oxidation, against which there is absorbed only the comparatively feeble heat of decomposition of PbS. The equation may be discussed as



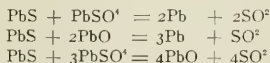
The net heat evolved in the equation is 240,120 — 40,400 = 199,720 Calories, which is 33,290 Calories per unit weight (16 kg.) of oxygen used, or 418 Calories for each kilogram of lead sulphide oxidized. This great heat of oxidation, evolved in roasting, is quite sufficient, in fact more than sufficient, to provide the heat required for self-roasting without the use of any other fuel, the chief difficulty is really to keep the charge from getting too hot and melting everything down to a liquid before the roasting is anywhere near complete. In the ordinary hand-worked reverberatory roaster, the oxidation is so slow that the fire on the grate really controls the temperature on the hearth, and the temperature of the roasting ore can be regulated accordingly. Where the roasting is done quickly, by an air blast, as in "Pot Roasting," the temperature is kept down somewhat by previously roasting off part of the sulphur, or by liberally wetting the charge, or by using limestone in with the ore, to absorb by its decomposition into CaO and CO² a large part of the excess heat—while the melting down of the charge is prevented by the mechanical interference presented by intermixed, inert and infusible material, such as silica, lime, etc., which simply prevents the really melted globules of sulphide from running together and thus melting down to a liquid mass.

An interesting variation is the roasting of lead sulphide to sulphate; some of this always forms, due to the high formation heat and difficult decomposability of the sulphate.

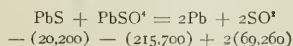


The net heat evolved is 215,700 — 20,200 = 195,500 Calories, or 48,875 Calories per unit weight (16 kg.) of oxygen used, or 818 Calories for every kilogram of lead sulphide so oxidized. This is a high heat of oxidation, and explains the great tendency to form sulphate observed during roasting. If the conditions could be found whereby only this reaction occurred, the sulphate roasting could be easily made automatic without outside fuel. There is needed, at the present time, a careful laboratory investigation of the conditions, mechanical, physical, chemical and thermal, for the roast exclusively to sulphate—just as a bit of badly needed metallurgical information.

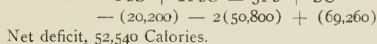
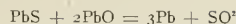
Double Reactions.—A large part in the metallurgy of lead is played by double reactions, such as the following:



On roasting lead sulphide for a short time, either lead or lead sulphate or mixtures of these are formed, according to the temperature and excess of air provided. With large excess of air and low temperature, and especially in presence of infusible materials which act as catalyzers (*i. e.*, which promote the union of SO² with O, and consequent formation of SO³ and PbSO⁴), sulphate may be formed almost exclusively. If the temperature is then raised, the tendency of PbSO⁴ to react upon the undecomposed PbS rapidly gets stronger, until at an orange heat this takes place rapidly and fairly completely, forming the one single gaseous product, SO².



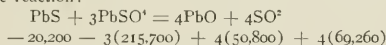
Net deficit, 97,380 Calories.



Net deficit, 52,540 Calories.

In both these cases the well-known phenomena of an endothermic reaction are manifest—the high temperature and strong firing necessary, and the formation of a single gaseous product from non-gaseous materials, assisting the reaction.

The reaction:



Net deficit, 187,060 Calories.

is supposed to take place in "pot roasting" where excess of air is blown through the finely divided material, but it is too endothermic a reaction to take place in a pot-roasting operation to more than a very subsidiary extent.

Oxidation Refining.—Impure lead is refined or "softened" by oxidation at a red heat. We must expect a great deal of lead to be oxidized in this operation, simply because of its preponderating mass, but the impurities present will oxidize relatively faster or slower than lead in proportion as their affinity for oxygen is relatively greater or less. The skimmings or slags obtained during softening are always principally composed of lead oxide, PbO, but they come off containing, in order, zinc, tin, antimony, arsenic, bismuth and small quantities of silver. During cupellation down to silver, which is continued oxidation until all the lead is oxidized, bismuth oxide is concentrated in the last parts of lead oxide formed, which may also carry silver in small amount; before this happens, however, the litharge formed is almost chemically pure.

The converse of these oxidation reactions also holds, *viz.*: differential reduction. Taking a softening skimming rich in antimony, for instance, it is possible by mixing it with a small amount of reducing agent, such as carbon, to reduce out of it all the silver and considerable of the lead which it contains without reducing much antimony. This leaves the remaining unreduced material desilverized and poorer in lead, or richer in antimony, and on subsequent reduction of this by excess of reducing agent a rich antimony-lead alloy is obtained. The easy reducibility of lead oxide is complementary to the slow oxidation of lead; both facts are clear from the heat of formation of the various metallic oxides, and both are extensively utilized in the metallurgy of lead.

THE VOLATILITY OF LEAD.

The melting point of lead is 326°, its mean specific heat in the solid state 0.02925 + 0.00009t, heat in melted lead at its melting point 11.6 Calories, latent heat of fusion 4.0 Calories, heat in just melted lead 15.6 Calories, specific heat in the liquid state 0.042—and approximately constant—boiling point at normal atmospheric pressure about 1,800° C., latent heat of vaporization, calculated by Trouton's rule (23 T) 47,680 Calories per molecular weight = 230 Calories per kilogram, assuming the vapor monatomic, specific gravity of vapor 103.5, referred to hydrogen gas at the same temperature and pressure, or, theoretically, 9.315 kg. per cubic meter at 0° C. and 760 mm. pressure, as a standard datum.

The question of the volatility of lead at other temperatures than 1,800° C. is highly important in the smelting of lead ores, yet is practically an unknown datum. The following is an attempt to calculate these data, so important in practical metallurgy:

The vapor tension curve of mercury is known for very low and up to comparatively high pressures. A rule has been observed between mercury and water vapor, in that the absolute temperatures at which these two substances have the same vapor tensions are found to stand in the ratio 1.7 to 1 through a large range of temperatures. Since lead vapor is in all probability monatomic, like mercury vapor, we will deduce the vapor tension curve of lead from that of mercury, using the constant ratio derived from the two temperatures at which their respective vapors have atmospheric tension, *viz.*:

$T_{Pb} = \frac{1,800 + 273}{357 - 273} = \frac{2,073}{630} = 3.3$
$T_{Fe} = \frac{1,800 + 273}{357 - 273} = \frac{2,073}{630} = 3.3$

The following table gives the most reliable data for the vapor tension curve of mercury, and the corresponding data calculated for lead, assuming the constant ratio 3.3 between the absolute temperatures at which they have the same vapor tension:

Tension of Vapor mm. of Hg.	Mercury C°	Lead C°
0.0002	0	625
0.004	33	735
0.045	67	844
0.28	100	954
1.47	133	1,064
5.73	167	1,173
18.25	200	1,283
50.	233	1,393
106.	267	1,502
242.	300	1,612
484.	333	1,722
760. = 1.0	357	1,800
840. = 1.1	367	1,841
1588. = 2.1	400	1,951
4.3	450	2,116
8.0	500	2,280
13.8	550	2,445
22.3	600	2,609
34.	650	2,774
50.	700	2,938
72.	750	3,103
102.	800	3,267
137.5	850	3,436
162.	880	3,525

From the above table a vapor pressure curve of mercury and lead can be constructed. An examination of the data shows that lead is certainly volatile to a minute extent at a low red heat, and that a current of inert gas passing across the surface of melted lead at that temperature certainly carries away vapor of lead; at the melting point of silver the tension is only about one-quarter of a millimeter, or one three thousandth of an atmosphere, yet this means that each cubic meter of inert gas carries off one three thousandth of its volume, or one-thirtieth of 1 per cent of its volume, of lead vapor. At 1,300°, the temperature of a commercial zinc retort, or of a lead smelting furnace, the tension is about one-fortieth of an atmosphere, which would mean that any other gas or vapor could carry 2.5 per cent of its volume of lead vapor with it. It must be remembered, moreover, that such gas saturated with lead vapor if suddenly cooled does not deposit its excess of lead vapor as liquid lead, but that a suspension similar to hoarfrost almost inevitably results, the so-called "lead fume," which is simply molecularly divided liquid or solid lead carried in suspension by a current of gas. The lead vapor is thus almost entirely carried out of the furnace without condensation and deposition.

Looking at the higher pressures, we can understand why an explosive reaction results when PbO is reduced by finely divided aluminium, the "aluminothermic" reaction. The immense heat liberated in the reaction,



220,000 Calories, raises the products to an electric furnace temperature, to some 3,000° C., at which temperature the lead vapor has a maximum tension, according to our table, of 60 atmospheres. No wonder then, that when Tissier tried this test for the first time, in 1857, using a piece of sheet aluminium weighing less than 3 grams (0.1 ounce), "le creuset a été brisé en mille pièces et les portes du fourneau projetées au loin"—the crucible was broken into a thousand pieces and the doors of the furnace blown to a distance.

A Modification of the Induction Furnace for Steel Refining.

We have noticed repeatedly in our columns the work which has been done with the electric induction furnace for steel refining on the Roehling iron and steel works in Voelklingen, Germany (our Vol. V., pp. 92 and 172). In *Stahl und Eisen* of Nov. 6, Geheimrat Prof. H. WEDDING describes a new development in the design of the induction furnace due to Messrs. 11. ROEHLING and RODENHAUSER. This furnace is intended to refine molten steel received from the basic lined converter and to produce in continuous operation soft iron which is at least equivalent to Swedish soft iron. Prof. Wedding and others had an opportunity to see the furnace in operation. During this inspection heats of very different character were made. According to the desires of the visitors sometimes a very hard, sometimes a very soft and sometimes medium hard steel was made and cast into molds of different forms. In all cases the steel from the basic lined converter was the starting

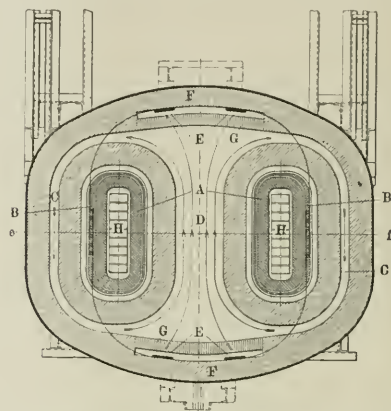


FIG. 1.—HORIZONTAL SECTION OF ROEHLING-RODENHAUSER FURNACE

material. It was supplied to the electric furnace in molten form, and was not only decarburized but also deoxidized and recarburized, that is, a soft steel as used for structural purposes, etc.

The chief new feature of the Roehling-Rodenhauser furnace, which distinguishes it from the Colby-Kjellin design, is that it combines two methods of electric heating; first, the ordinary heating by electric induction currents, while the second kind of heating also employs induction currents, which, however, are introduced into the molten bath through metal plates, called electrodes. This second method of heating has, therefore, some similarity with ordinary alternating-current resistance furnace practice.

The furnace is shown in Figs. 1, 2 and 3. Fig. 1 is a horizontal section along the line a b of Fig. 3. Fig. 2 is a vertical section along the line c d of Fig. 3, while Fig. 3 is a vertical section along the line e f of Fig. 1. The furnace is designed for a 5-ton charge, to be operated at 5,000 volts with a frequency of 15 periods per second.

Like the ordinary induction furnace, this furnace is essentially a transformer with a single primary winding A around both iron cores H of the transformer. The secondaries are two in number, one is the molten bath C in form of a ∞ , the channel D between the two cores being very broad. The other secondary is the copper winding B, which is connected with the metal plates E. These metal plates are inserted into the furnace walls F in such a way that the currents pass from the

winding B through the plates E, and through the mass G of highly refractory electrolytic conductors (of the same nature as used as filaments in the Nernst lamp) to the molten mass D. In this way the molten mass D is subjected to a double heating effect, one direct by induction and the other from the currents passing between the opposite sets of electrodes E. The direction of the currents in the bath at a certain moment is indicated by arrows in the illustration.

In order to protect the windings against the effect of high temperatures, thin-walled copper cylinders M M (Fig. 3) are provided, through which is conducted an air blast passing out of the tubes N₁N₂. The transformer iron contains ventilation slits H (Fig. 1). These methods of cooling have been found to be perfectly sufficient during several months operation.

The charging door is at one end of the furnace, the tapping door at the other end. On account of the method of operation of the furnace the molten charge is kept in sufficient circulation so that all manual operations are restricted to taking care of the right formation of slag and to the tapping of the slag. As shown in Fig. 2 the whole furnace is built as a tilting furnace. In its general design the furnace is built very much like a Siemens-Martin open-hearth furnace.

The normal charge is 3 to 3½ tons, but about 800 kg. are left at the end of a heat in the furnace, so that the new charge consists of only 2½ tons. This is being done in order to keep the furnace hot, when after the conclusion of heat no fresh charge is yet ready for introduction from the converter in the electric furnace.

The operation of the furnace is as follows: After providing a basic lining of magnesia with 10 to 12 per cent tar of the hearth and around the transformer cores (the arch consisting of fire-brick), the inside of the furnace is first strongly heated. For this purpose rings of soft steel are placed in the furnace, which are heated to 900° to 950° C. by induction currents. As soon as the furnace stops to give off smoke (the hydrocarbons from the tar having been given off), fluid pig iron is introduced from the blast furnace. The electric circuit is then closed and the temperature begins to rise slowly. After 18 hours the furnace is up to full heat and there is no longer any smoke.

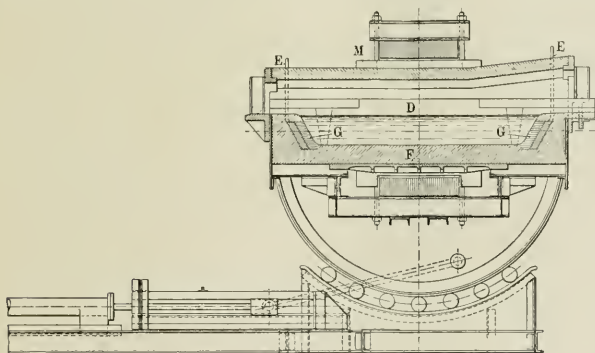


FIG. 2.—VERTICAL SECTION OF ROEHLING-RODENHAUSER FURNACE.

The molten pig iron is then removed by tilting the furnace, only 800 kilograms remaining back, and now the finished steel from the basic converter is introduced. Burnt lime is placed on this bath. The lime used contains 6 per cent magnesia. About 8 kilograms of fluorspar are added to get a sufficient degree of fluidity in view of the comparatively high content of magnesia. Refining now begins. If the slag becomes too fluid, lime is added; if too thick, fluorspar.

The operation is completed when no longer bubbles rise up from the liquid bath, and when samples taken from the

bath give satisfactory tests. The slag, which contains generally 25 per cent of iron in form of oxides, is removed, and a pure lime slag is formed from fresh burned lime and fluorspar and deoxidation begins now by means of ferro-silicon. Samples are taken again and tested. If the intention is to make high-carbon steel, powdered coke is added to the furnace, which quickly dissolves in the bath, otherwise spiegel-eisen is added as usual.

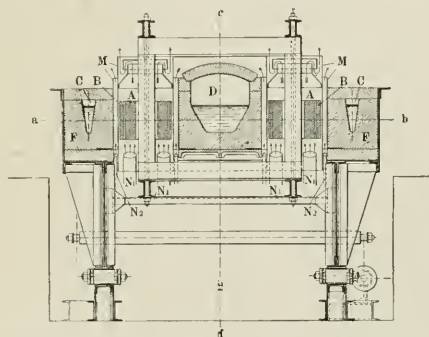


FIG. 3.—VERTICAL SECTION OF ROEHLING-RODENHAUSER FURNACE.

The final slag has the following composition:

	Per Cent.		Per Cent.
FeO	5.32	Fe ₂ O ₃	0.94
MnO	0.9	Al ₂ O ₃	1.27
CaO	67.82	MgO	3.88
SiO ₂	0.97	P ₂ O ₅	0.6
S	0.9		

The alumina comes evidently from the fire-brick of the arch.

To make hard steel free from sulphur the steel must be left in the furnace for a longer time, and the sulphur must be removed by oxidation or manganese and a suitable fluid slag.

As analyses show, the sulphur may be completely removed in that way. Very small quantities of manganese are sufficient, but it is necessary to employ a high temperature, which can be accomplished easily by raising the voltage.

Compared with converter steel the electric steel when being cast runs exceedingly quiet, which is due to the fact that the steel has a very high temperature during casting.

With the electric furnace it is possible to remove completely all impurities from the steel. If the object is to bring the content of phosphorus below 0.02 per cent it is necessary to remove the second slag and form another third slag like the second. If the content of silicon has become too high it is easy to reduce it again by an addition of "Walzsinter," lime and fluorspar.

A complete removal of silicon should, however, not be attempted, because otherwise the iron does not get sufficiently dense in the mold. In spite of a content of 0.085 per cent silicon with 0.47 per cent manganese, a very quietly running and thoroughly dense steel is obtained when the content of carbon is only 0.01 per cent. An analysis showed in such a steel 0.03 per cent of phosphorus and 0.77 per cent of sulphur.

Each heat lasts in general for 2 to 3 hours. Two men are sufficient to do the work at the furnace while a third man attends to the electrical equipment. During tapping the circuit is broken so that the current, e. m. f. and power become zero.

Otherwise they remain practically constant during operation and are regulated only if for some purpose it is intended to raise or reduce the temperature. The conditions during a heat which begin at 10.50 A. M. is given in the following table:

Hours.	Minutes	Volts	Amperes.	Kilowatts.
10	50	2,000	145	330
11	00	2,800	150	365
11	10	3,000	105	430
11	20	3,000	105	430
11	30	3,200	170	460
11	40	2,800	152	375
11	50	2,000	142.5	315
12	00	2,000	142	330
12	10	2,400	128	250
12	20	2,400	130	270
12	30	2,400	131	210
12	40	2,400	131	210

Tapping was then begun, and after a new charge had been introduced the conditions were as follows:

Hours.	Minutes.	Volts.	Amperes.	Kilowatts.
12	55	2,600	40	80
1	00	2,600	130	310

The above figures show that the power factor is quite satisfactory. At 2,600 volts with a current of 145 amps. the volt amperes were 377,000, or 377-kv. amperes, while the kilowatts were 330. The power factor (or the cosine of the phase difference between *e. m. f.* and current) was therefore 0.875. Several analyses and results of mechanical tests are given.

Concerning the cost of the process, figures are given for a 5-ton furnace, and it is found that the total cost of refining 1 ton of soft steel in the electric furnace (including interest and amortization, but not including license fee) is \$5.83.

The final conclusions of Prof. Wedding are as follows: "This process, like other electric steel processes, serves simply for refining. It enables one to remove the last impurities from the steel and to introduce any amount of carbon and other elements. Above all things the electric furnace is a substitute for the crucible process by removing all gases, but has not the disadvantage of the crucible process, namely, the absorption of silicon from the crucible walls. If the product is worth about \$6.00 more per ton than the converter steel which is introduced into the furnace, the process is economical on a large scale. That the product is worth so much more must be concluded from the denser structure which manifests itself at the very high temperature, and which has an influence on the condition of the carbon that still remains to be investigated.

Dry Blast at Pottstown.

As noticed in our Vol. V., page 290, the Warwick furnace No. 2, at Pottstown, Pa., has been equipped for running with dried blast by the Gayley system. From the records of Mr. E. F. Cook and his engineers it is evident that the installation has proven very successful. By comparison of the operation of the furnace with natural air blast and with dried air blast, it appears that the introduction of the dry blast system has resulted in an increase of 5 per cent in the output and a decrease of 11.7 per cent in the consumption of coke per ton of iron. But this is not all.

The furnace was about to be blown out at the end of August, but since the dry blast installation had then been finished it was hoped that the new method would prolong the life of the furnace for a time sufficient to finish certain urgent contracts for basic iron. This has proved true, and it is estimated that the life of a lining is prolonged by 32 per cent by the dry blast method. Moreover, it was found that an unexpectedly high increase in percentage of the desired grade of metal was obtainable with the new process.

Application of the Laws of Physical Chemistry in the Metallurgy of Iron.

By PROF. BARON HANS JÜTTNER VON JONSTORFF.

(Concluded from Vol. V., p. 502.)

III.

We will now employ the views obtained in the previous chapters to the consideration of blast-furnace practice.

In the lower part of the blast furnace the oxygen of the air acts on the FeO, the coke and the metallic iron. The temperature at the tuyere level is, according to Le Chatelier, about 2,200° absolute; the blast is at a pressure of a little over 1 atmosphere. We can take it here for simplicity = 1 atmosphere. The tension of dissociation of FeO is at this temperature 0.05 atmosphere ($\log [O_2] = -1.3054$), whilst that of iron oxide is much greater. Since the oxygen pressure of the blast is 0.2 atmosphere ($\log [O_2] = -0.6990$), the iron in front of the tuyeres can still be oxidized. On the other hand, we have for the dissociation pressure of CO at this temperature:

$$\log [O_2]_{co} = -9.2099 - 2 \log [CO];$$

and for that of carbonic acid:

$$\log [O_2]_{co_2} = -3.0894 - \log [CO_2].$$

Both will become larger than that of FeO if the partial pressure of the CO should be under 0.0001 atmosphere, but that of CO₂ under 0.01 atmosphere, which, however, for CO need not be considered in the case of the blast furnace. Consequently, the oxygen of the blast can only oxidize the carbon, and not in any way the reduced iron.

We have thus in this zone only to take into consideration the influence of the oxygen of the blast and the FeO upon the fuel.

If there is, as in the normal working of the furnace, no more FeO present, the reactions of the furnace are the same as in an ordinary producer, in which the temperature, of course, is extremely high. Therefore, only CO can be formed, and the maximum pressure of this is 0.347 atmosphere.¹

Moreover, since the moisture of the air acts in an oxidizing manner on the coal, whereby hydrogen, and possibly hydrocarbons, are formed, this CO pressure must become even still smaller. (We will, however, here, for the sake of simplicity, neglect this influence of water vapor.) In accordance herewith most furnace gases show, as a matter of fact, when taken at this horizontal position in the furnace, or at a little above it, a percentage of CO of less than 34.7 per cent by volume, which proves that in the furnace zone we are considering no more FeO is present. If it were so, then by the comparison of the CO and CO₂ a not inconsiderable tension of dissociation of the FeO of this oxidizing effect must react on the coal, and "direct reduction" takes place. By this an increase of the percentage of CO and of the counter pressure in the blast furnace will take place. But the formation of carbonic acid in this part of the furnace, assuming equilibrium, can only take place if higher oxides of iron, with sufficiently large tensions of dissociation, are present.

Such cases, as a matter of fact, have often been observed, and show that FeO, or a higher oxide, was present. They would be specially observable if from any cause the oxidizing influence of the blast should be weakened.

During the tapping the blast is taken off; there is, therefore, only the influence of any FeO, etc., present on the fuel, and a sample of gas at this period, which was taken at the tuyere level of a blast furnace, contained

1.0.21 vol. of oxygen in the blast gives.....	0.42 vol. CO.
The nitrogen therewith is.....	0.79

1.21

The percentage of CO is therefore $42/1.21 = 34.7$.

	Before Tapping.	After Tapping.
	Per Cent.	Per Cent.
Nitrogen	67.70	57.56
Carbonic acid.....	1.19	2.96
Carbonic oxide.....	29.33	38.22
Hydrogen	1.62	1.17
Methane	0.03	0.09

Before tapping, the percentage of carbonic oxide is under 34.7 per cent. but the appearance of carbonic acid shows that at the temperature prevailing at the tuyere level, in the case of the equilibrium for the system air + coal, the possible existence of FeO, or even of Fe_3O_4 , is impossible. After tapping, on the contrary, the percentage of carbonic acid increases to more than double, and, moreover, the percentage of carbonic oxide considerably² exceeds the value of 34.7 per cent.

Since the gas stream is going off through the furnace shaft with considerable velocity, the influence of the blast under the tuyeres (for example, in the tump) will be less noticed. The influence of direct reduction must here also be clearly shown. Consequently, there was found in this part of the furnace the following composition of gas:

Blast Furnace at l'ienne.

	Per Cent.
Nitrogen	61.07
Carbonic acid.....	0.68
Carbonic oxide.....	36.84
Hydrogen	1.41

Blast Furnace at Hasselfors.

	Per Cent.
Nitrogen	20.8
Carbonic acid.....	1.4
Carbonic oxide.....	75.9
Hydrogen	1.9

Blast Furnace at Forssjö.

	Per Cent.
Nitrogen	60.3
Carbonic acid.....	1.4
Carbonic oxide.....	36.7
Hydrogen	1.6

Blast Furnace at Hammarby.

	Per Cent.
Nitrogen	60.2
Carbonic acid.....	0.5
Carbonic oxide.....	37.6
Hydrogen	1.7

Blast Furnace at Clerval.

	1841.	1848.
	Per Cent.	Per Cent.
Nitrogen	47.40	58.17
Carbonic acid.....	0.93	0.93
Carbonic oxide.....	51.35	39.86
Methane	1.25	0.25
Hydrogen	0.09	0.79

With larger hearths the oxidizing influence of the blast opposite the tuyeres must be less, and therefore that of any iron oxide still present be clearly shown. Thus Ebelman found in the blast furnace at Audicourt at this place:

	Per Cent.
Nitrogen	50.58
Carbonic acid.....	0.90
Carbonic oxide.....	48.52
Hydrogen	0.90

² That here, moreover, the equilibrium would not be reached in both cases, is shown by the calculation of the log of the tension of dissociation.

	Before Tapping.	After Tapping.
Log [O ₂] CO	- 8.7354	- 8.8504
Log [O ₂] CO ₂ = CO + O ₂	+ 2.3351	+ 2.3351
Log [O ₂] CO ₂ = C + O ₂	- 2.9338	- 3.3296
Log [O ₂] FeO	- 1.9830	- 1.9830
Log [O ₂] Fe ₃ O ₄ = 3FeO + O ₂	+ 3.4248	+ 3.4248
Log [O ₂] Fe ₃ O ₄ = 3Fe + 2O ₂	- 0.6311	- 0.6311

Temperature of furnace = 1,700° C., or nearly 2,000° absolute. These figures show, moreover, that higher oxides of iron must be present.

As the stream of gas ascends its temperature decreases, and, therefore, also the oxygen dissociation pressure of the FeO, as well as that of the carbonic oxide and carbonic acid. So long as the oxygen pressure of the reaction $\text{CO}_2 = \text{CO} + \text{O}$ remains greater than the tension of dissociation of the ferrous oxide, the carbonic oxide can exercise no reducing influence on the latter, whilst direct reduction will always be noticed. This shows itself from the fact that the CO percentage of the gas above the tuyere level is also still greater than 34.7 per cent, as, for example, in the blast furnace at Alfreton, 0.64 meter above the tuyeres.

	Per Cent.
Nitrogen	58.05
Carbonic acid.....	0.21
Carbonic oxide.....	37.43
Hydrogen	3.18
Cyanogen	1.34

Or at one at Audicourt, 2.5 meters above the tuyeres:

	Per Cent.
Nitrogen	61.61
Carbonic acid.....	0.21
Carbonic oxide.....	36.38
Hydrogen	1.79

Or at the blast furnace at Clerval:

	1.05 m.	Above the Tuyeres.	
	Per Cent.	Per Cent.	Per Cent.
Nitrogen	61.22	63.06	63.04
Carbonic acid.....	0.07	0.07	0.49
Carbonic oxide.....	37.55	35.47	35.05
Methane	0.10	0.31	0.36
Hydrogen	1.13	1.09	1.06

So also the increase in the percentage of carbonic oxide in the gas with the increasing height above the tuyeres is shown in the following examples:

	—Blast Furnace at Forssjö—			—Pont l'Évêque—		
Above tuyeres.	2.51 m.	3.69 m.	5.06 m.	0.24 m.	0.29 m.	0.67 m.
	%	%	%	%	%	%
Nitrogen	62.4	62.1	61.2	75.10	71.20	62.70
Carbonic acid.....	3.2	2.2	2.9	8.11	5.86	0.16
Carbonic oxide.....	32.0	33.7	34.9	16.53	22.25	36.15
Hydrogen	2.4	2.0	1.0	0.26	0.68	0.99

If in the upper parts of the blast furnace the temperature has sunk so far that the oxygen pressure of the reaction CO_2 (equal to $\text{CO} + \text{O}$) is smaller than the tension of dissociation of FeO, the reduction is effected by carbonic oxide, whereby the percentage of carbonic oxide in the gas is lowered whilst the carbonic acid increases. Thus, for example, Ebelman found:

	Blast furnace at Seraing.					
	0.72 m.	10.77 m.	11.38 m.	11.69 m.	13.21 m.	14.13 m.
	%	%	%	%	%	%
Nitrogen	54.63	61.34	61.15	62.46	59.64	57.06
Carbonic acid.....	0.10	1.13	1.54	9.85	11.39	
Carbonic oxide.....	45.05	30.30	35.35	33.88	28.06	28.61
Methane	0.07	0.25	0.20	1.43	1.48	0.20
Hydrogen	0.25	2.01	2.08	0.69	0.97	2.74

Finally the gas in the upper parts of the furnace comes into contact with iron in a higher oxidized condition and reduces this to FeO, because the tension of dissociation of Fe_3O_4 to $3\text{FeO} + \text{O}$ is very high.³

Moreover, at a lower temperature the tension of dissociation of carbonic oxide can be greater than that of carbonic acid, and then the breaking up of 2CO into $\text{CO}_2 + \text{C}$ takes place. But

³ Under certain conditions, as mentioned above, an oxidation of FeO can take place, by means of which perhaps certain irregularities which are found in the analysis of furnace gases from furnaces of varying cross-section may be explained. Thus at 800° absolute the oxygen pressure of the reaction $\text{FeO} = 3\text{FeO} + \text{O}$ is smaller than the tension of dissociation of FeO. Below this temperature an oxidation of the latter is therefore possible.

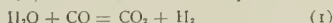
this is only possible when the dissociation pressure of the oxide of iron present has become smaller than that of $\text{CO}_2 = \text{CO} + \text{O}$.

But since this latter is dependent upon the ratio of CO to CO_2 , this will, at a relatively lower temperature, be responsible for the appearance or the non appearance of that very unwelcome reaction. The greater this ratio is—that is to say, the less carbonic acid there is present to the carbonic oxide, or in other words, the less the carbon in the blast furnace is employed for reducing—the higher lies the temperature at which this reaction begins to occur and the more harmful is its influence.

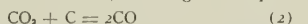
As we have already seen, the ratio of CO to CO_2 is independent of the pressure. It forms, therefore, an excellent means of judging of the working of the blast furnace, for which purpose it has long since been employed by Gruner.

If moist air be employed, as is usually the case, the water vapor is decomposed by the incandescent fuel, and the furnace gases will be mixed with H_2 and also with CH_4 , both of which reduce ore.

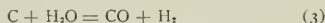
The next influence will be this, that the temperature in front of the tuyeres, in consequence of the heat absorbed by the decomposition of the steam, will fall considerably, and thereby the tension of dissociation of the bodies present be lowered. Moreover, there will quickly take place an equilibrium between CO , CO_2 , H_2 and H_2O , in accordance with the equation



But, on the other hand, carbonic oxide and carbonic acid stand in equilibrium with the carbon, according to the equation



whilst the decomposition of the water takes place according to the equation



For these reactions the conditions of equilibrium are:

$$\text{For (1)} \quad \frac{[\text{CO}_2] [\text{H}_2]}{[\text{CO}] [\text{H}_2\text{O}]} = K_1$$

$$\text{For (2)} \quad \frac{[\text{CO}]^2}{[\text{CO}_2]} = K_2, \text{ or } [\text{CO}] = \frac{K_2 [\text{CO}_2]}{[\text{CO}]}$$

$$\text{For (3)} \quad \frac{[\text{CO}] [\text{H}_2]}{[\text{H}_2\text{O}]} = K_3, \text{ or } [\text{CO}] = \frac{K_3 [\text{H}_2\text{O}]}{[\text{H}_2]}$$

Since the equilibrium of both CO pressures must be equal, we obtain for (1):

$$K_2 \frac{[\text{CO}_2]}{[\text{CO}]} = K_3 \frac{[\text{H}_2\text{O}]}{[\text{H}_2]}$$

From this it follows:

$$\frac{[\text{CO}_2] + [\text{CO}]}{[\text{H}_2\text{O}] + [\text{H}_2]} = \frac{K_2 [\text{CO}_2]}{K_3 [\text{H}_2\text{O}]} \text{ or } \frac{K_2}{K_3} \frac{[\text{CO}_2]}{[\text{CO}_2] + [\text{CO}]} = \frac{[\text{H}_2\text{O}]}{[\text{H}_2\text{O}] + [\text{H}_2]}$$

Now $[\text{CO}_2] + [\text{CO}]$ corresponds to the quantity of carbon burnt, and $[\text{H}_2\text{O}] + [\text{H}_2]$ to the original water vapor present.

And since the CO_2 percentage in the gas corresponding to the higher temperature in the lower part of the blast furnace and to the hydrogen equilibrium is excessively small, the partial pressure of the water vapor must also be so, and the hydrogen can thus exercise so much the less a strong reducing influence upon the ore, as the quantity of carbon burnt is in every case much greater than the moisture of the air.

From this it follows that the presence of water vapor in the blast furnace can produce no special advantage. But, moreover, the water vapor by its decomposition uses up carbon, but

on the other hand the hydrogen present will decrease the partial pressure of CO and CO_2 and their tension of dissociation, under these conditions, at least in the lower part of the blast furnace, the presence of water vapor will ever act detrimentally. So that it would appear that the experiments made to dry the blast before its introduction into the blast furnace are well founded.

These considerations touch only a few of the points involved in blast-furnace practice, but they are sufficient to show that the new method of view serves not alone to broaden our understanding of the various chemical processes involved in blast-furnace phenomena, but also in many cases to gain new enlightenment.

Gas-Electric Power at the Mansfeld Copper Mines and Smelting Works.

Mining operations started in the famous Mansfeld district in Germany as early as 1200 and assumed considerable importance under the judicious management of the Counts of Mansfeld. The whole district soon became an important mining camp, though not in our Western sense. It is well known, for instance, that Luther's father, in Eisleben, was a miner. The operation stopped almost completely during the thirty years' war from 1618 to 1648. Later on operations were again taken up by a great number of small independent operators, but a new era began in 1852, when the independents combined to found the Mansfeld'sche Kupferschieferbauende Gewerkschaft, which was reorganized in 1876, and has made constant progress under excellent management.

The deposit of Kupferschiefer (copper schist) covers a very extended area but is only 2 or 3 feet thick. It is a bituminous schist with 1.8 to 3.7 per cent of copper in form of sulphuretted copper ores and a small proportion of silver equal to 0.53 to 0.72 per cent of copper present. The copper schist contains besides 40 per cent silica, 10.7 per cent alumina, 5.0 per cent iron oxide, 19.5 carbonate of lime, 2 carbonate of potash, and 10.3 water and bitumen.

The metallurgical treatment adopted at Mansfeld is well known. To describe it in the words of Schnabel, the ore is calcined in heaps to remove water and bitumen, and is smelted in shaft furnaces yielding coarse metal with 30 to 40 per cent copper. This is calcined in kilns and smelted in reverberatory furnaces, forming a matte with 74 to 76 per cent copper and on an average 0.45 to 0.48 per cent of silver. This is treated by Ziervogel's process, and the residue, consisting of oxide of copper and a little oxide of iron, is mixed with coal, reduced in reverberatory furnaces and refined direct. During 1906 the production was 20,000 tons of copper and 100,000 kg. of silver.

The circular shaft furnaces mentioned above have a crucible hearth and are from 24 to 29 feet 6 inches high and have six tuyeres. The diameter of the furnace at the tuyeres is from 5 feet 3 inches to 6 feet 2 inches, and at the throat 7 feet 3 inches. There are four flues at the top to take the gases off into the gas main, where it was formerly used for raising steam and in several of the furnaces for heating the blast.

Until lately all the machinery scattered over an area of more than 25 square miles—which is the present extension of the mines—was driven by steam engines with a large number of boilers distributed over this area. The advantages of supplying electric power over this area were so manifest that the question of using the furnace gases in gas engines for the generation of electric power were carefully studied, and after preliminary investigations and experiments had been successful, the complete electrification of the mines and the smelting works was decided upon. In three recent issues of *London Electrical Engineering* we find a very interesting article by Mr. H. R. SPEYER on the present electric equipment of these mining and smelting works, and from this article the following summary has been prepared.

The three principal copper smelting works in the order of their importance are the Krughütte, the Kochhütte and the Eckardthütte, and the underlying idea of the scheme is to erect generating stations at these three places and connect the three stations by means of underground cables by a ring trunk main, so that, in the event of a breakdown occurring in any one, the remaining two will still send energy over the whole system. The total length of the ring is 13.87 km. (over 8 miles). This scheme was, however, extended by erecting a fourth station at the Kupferschieferhütte, which is steam driven, because the blast-furnace gas at this works is too poor in calorific value. The gas is used, however, for firing one of the two batteries of boilers.

Underground cables were chosen for the ring line because the routes pass through a great number of villages and along highways, and in order to avoid disturbances due to the very frequent severe local thunderstorms.

The following table gives the percentage of carbon monoxide in the blast furnace gases of the three plants, the number of cubic meters of gas per hour and the maximum and minimum horsepower available in the three gas-driven stations:

	<i>Cubic Meters</i>	<i>Maxim.</i>	<i>Mini'm</i>	
<i>% CO.</i>	<i>Per Hour.</i>	<i>Hp.</i>	<i>Hp.</i>	
Krughütte	21.65	21,000	4,500	2,700
Kochhütte	18.6	14,000	2,600	1,500
Eckardthütte . .	17.65	9,000	1,600	700

The horsepower available varies, because the furnaces are cut out from the main delivery gas pipe during feeding, tapping and cleaning, and it sometimes happens, in spite of efforts to the contrary, that these operations are carried out on more than one furnace simultaneously. Further, the calorific value of the gas may at times decrease by as much as 10 per cent.

The gas as it leaves the furnace is absolutely unsuitable for direct use in gas engines owing to the presence of a large quantity of finely divided dust. It is, therefore, cleaned in Theisen centrifugal contraflow washers. Before entering the washers the gas contains 17 grams of dust per cubic meter, namely, 0.83 per cent copper, 0.01 silver, 33.12 lead, 0.75 arsenic, 22.5 insoluble zinc, 2.5 soluble zinc, 2.84 sulphuric acid, 13.97 sulphur, 6.14 silicon and 2.40 carbon. Traces of Cl_2NH_3 , cadmium and manganese are also present.

After cleaning only 0.003 grams of dust are contained per cubic meter of gas. This dust is of similar composition except that the proportion of lead is increased to 41 per cent on account of the disappearance of the more soluble ingredients. The lead is present in the form of PbO_2 and the zinc as ZnS .

At present only the gas plant at Krughütte and the steam plant at Kupferschieferhütte are complete. The blast furnaces at the Krughütte are all connected to two parallel gas trunks, having an internal diameter of 1,600 mm. and 1,000 mm. respectively. They are so arranged that each and all can exhaust into either pipe while the other is being cleaned. These two gas trunks serve to lead the furnace gases to the purifier house, where three Theisen washers are installed. Their construction is shown in Fig. 1, which shows the general arrangement of one of these washers.

It consists of a conical metal casing (*A*) lined with wire gauze, within which a drum (*D*) fitted with spiral blades (*e*) revolves at a peripheral speed of 3,000 meters per minute. The blades of this drum are so formed at their ends (*f*) as to draw in the gas at one end of the casing (*C*) and expel it at the other (*c*). Water is admitted through the opening (*g*) at the side of the casing, and is finally sprayed by the blades, being caused by their spiral form to flow in the opposite direction to the motion of the gas. The water leaves the cleaner by the water seal (*h*), and is conducted to a settling tank. It may be mentioned that the deposit in the settling tanks contains at least 25 per cent of lead, which is afterwards recovered. The gas on leaving (*c*) is dried by being passed through a Theisen vapor separator.

The action of the apparatus is continuous, and as the bearings are fitted with ring lubrication, practically no attention is required. Before reaching the actual washer the gas is passed through a preliminary saturator, where some of the heavier dust is separated. The three washers at the Krughütte are together capable of dealing with over 30,000 cubic feet of gas per minute, and use in all approximately 200 gallons of water per minute. From the cleaning plant the gas passes into a gas reservoir having a capacity of 500 cubic meters.

The gas is supplied to two 1,300-hp. Oechelhäuser gas engines coupled to 3,000-volt three-phase generators, each of 1,080 kw.

The cables are designed partly for 3,000-volt and partly for 10,000-volt transmission. By means of transformers the lines of different voltage are connected together so that the whole transmission line forms one solitary unit. Almost along the whole ring the cables have been laid in duplicate to provide against the dangers of a breakdown.

The three-phase system, besides its other advantages for transmission, was specially chosen on account of the great reliability of working three-phase induction motors, with which there is no difficulty of starting (as with single-phase induction motors), and which on account of lack of any commutator are much more fool-proof and require much less attendance than

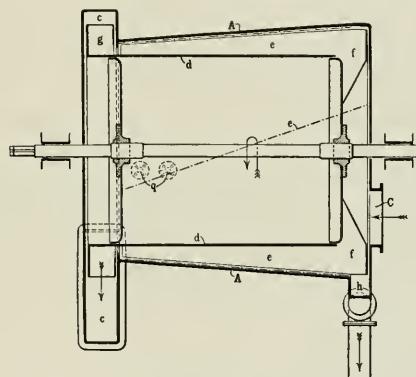


FIG. 1.—SECTION OF THEISEN GAS WASHER.

direct-current motors. In Krughütte the electric power is used for various purposes in the workshops and also for driving the rotary blowers which supply the forced draft to the furnaces. These induction-motor blower sets are kept running continuously day and night. The blowers are of extremely simple construction, and are entirely without valves. As the revolving parts do not come into actual contact the efficiency is comparatively high, being approximately 75 per cent. Each blower is designed for an output of 250 cubic meters of free air per minute at a pressure of 100 mm. of mercury. They run at a speed of 250 r. p. m. and each is belt-driven by a 125-hp. motor, running at 750 r. p. m. on the 3,000-volt, 50-cycle, three-phase circuit.

Smaller applications of three-phase induction motors at the same smelting works are for driving two centrifugal pumps, each with an output of 75 liters per minute, for circulating the cooling water of the furnaces, and for operating the molding machines in which the ore fines and dust are compressed into brick to be fed into the furnaces. The feeding mechanism of the furnaces is driven through chain transmission by three-phase motors. The gear for each furnace is capable of dealing with 3,000 550-kg. wagons per 24 hours.

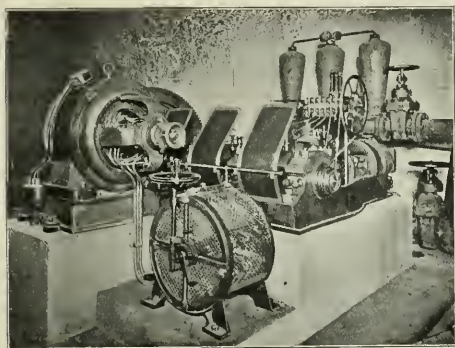
The Krughütte smelting works are connected with the Herrmann pit by an aerial steel rope 7 km. in length (over 4 miles), which is driven from a 10-hp. motor. A second motor

and so on until the maximum is reached. The form of the cam thus determines the rate of acceleration.

The driver is always able to draw back his lever for reducing the speed. If he forgets to do this at the right time towards the end of the wind, the lever is returned automatically by the cam, and the speed of the winder is retarded at a prescribed rate. The cam is of such a form that at the part corresponding to the end of the wind it returns the control lever automatically so far back that the speed falls to quite a small value, but from this instant the profile is concentric with the axis of the disc, so that the driver is able to use this slow speed in the neighborhood of the pit bank for the purpose of carrying out the necessary operations connected with the landing and starting of the cage.

The driver retains this power of carrying out the necessary operation at low speed up to the moment when the cage passes the bank. At this instant the profile of the cam makes an abrupt change, and rapidly returns the control lever to the off position. At the same instant a stop works upon an unlocking gear at the end of the run, which immediately puts on the safety brake, and the winding engine, which has already been slowed down, is brought entirely to rest.

It is thus seen that the safety apparatus compels the driver at each wind to adhere, whatever the load, to the rate of



ELECTRICALLY-DRIVEN PUMP IN ZIRKEL PIT.

working which has been prescribed. It in no way interferes with the driver, so long as he operates the levers correctly, but in every case resists an attempt to move them wrongly. The absolute security ensured by this apparatus has been recognized by the (Prussian) inspection commission for winding men in the mining district of Dortmund, who have given permission for the speed of winding to be raised from 6 meters per second, the maximum hitherto allowed, to 10 meters per second when winding men.

It is interesting to note that the actual working results have shown considerably increased economy, especially if the results at the electrically-operated Hermann pit are compared with the costs of the steam winding at the Niewand and Zirkel pits under similar circumstances. The steam power cost per ton-kilometer in the latter two varied between 11 and 9 cents per ton-kilometer from January to June, 1907, while the cost of electric power at the Hermann pit per ton-kilometer was only 4 cents. This cost, however, is in both cases only for the value of the actual energy consumed and does not in either case cover incidental expenses incurred during the six months. The results obtained with the electric winding plant in the Hermann pit have been so satisfactory that the electrification of the main winding gear in those other pits, which still have a number of years to run, is to be proceeded with at once.

At the Oberhütte motor a generator set is installed to supply direct current to an electrolytic refinery.

At the Hohenthal pit the underground roadways, which were formerly driven by compressed air supplied from a steam-driven air compressor, have been electrified with a very considerable reduction of cost of operation, the cost per horsepower being only one-fourth of the former method. The electrification has been carried out by using the fly-wheel of the air engine as the belt-driven pulley of the three-phase 3,000-volt 100-hp. motor. In all other respects the engine remains unchanged, with the result that the roadways can still be driven with the air engine should the necessity arise. The underground ventilators, the boring machines, as well as the workshops at the surface, are also electrically driven.

Since an influx of water was expected in this pit a complete electric pumping plant has been erected, but, unfortunately, the influx of water came at another place than had been expected. Nevertheless, should the water rise further it will be possible to employ this pumping plant.

The Zirkel pit, which lies outside of the actual cable ring, is supplied with 10,000 volts three-phase currents, which are transformed down to 3,000 volts at the pit mouth. At this pressure the current is taken down the shaft of the pit, a distance of 2,200 feet, by means of a three-core cable. At the fifth, and at present last seam, there is another transformer which further reduces the pressure of one circuit to 500 volts. At this voltage the motors are operated for working underground roadways.

The output of the largest ventilating fan in the Zirkel pit which is used for circulating air in the fourth seam, is 4,000 cubic meters per minute when working against a pressure of 100 mm. of water. The diameter of the blades is 10 feet. This fan is belt-driven by a 3,000-volt 185-hp. induction motor. In the same machine room is erected a 30-hp. 500-volt three-phase induction motor for driving a centrifugal pump used for pumping the water up to the storage tanks placed over bank at the surface. This pump is shown in Fig. 3. There are also three small ventilators driven by 30-hp. three-phase motors.

As will be seen from the above description the electrification of the mining and smelting works has not yet been completed, but in view of the excellent results so far obtained the further equipment of the works with electric power is going on.

The Duluth Power Development and Electro-chemistry.

We have repeatedly referred to the important development of power by the Great Northern Power Co. at Duluth. Since September the plant is in operation. While the present station has been designed for eight generating units of 10,000 hp. each, only three are at present working. But even after all eight units will have been installed, it will be possible, by new water-power developments, to increase the capacity still further to a total of 150,000 or 200,000 hp. The power plant is an excellent example of modern engineering practice. The entire electrical equipment has been supplied by the General Electric Co.

Twenty-two thousand electric horsepower have already been contracted for, partly for lighting and traction in Duluth and the neighborhood, but to a large extent for power purposes. Thus the great coal docks at the head of Lake Superior are to be electrically equipped, and many of the large manufacturing concerns in the neighborhood are expected to become customers of the power company. The United States Steel Corporation will be among them, since the power produced from by-product coke-oven gases, with the aid of gas engines, will not be enough to fill all requirements.

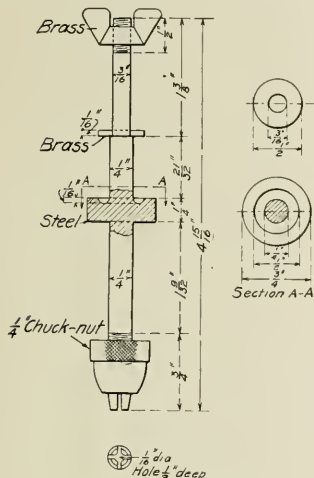
The American Carbolic Co., which makes calcium carbide under the patents of Mr. H. L. Hartenstein (our Vol. IV., pp. 237, 289, 369; Vol. V., p. 102), also gets electric power from the company. They are now operating nine electric furnaces, but will increase the number of these furnaces in the near future to twenty-one, each furnace requiring about 250 hp.

Electrochemical Analysis with Rotating Anodes in the Industrial Laboratory.

BY ANDREW M. FAIRLIE AND ALBERT J. BONE.

I.

The advantages of a rotating anode in electrochemical analysis were first brought into prominence by Exner¹ in 1903, although Smith,



ten blades, set at a 45° pitch, and is soldered to the stem with gold. The anode complete weighs about 6 grams.

In using the electrodes the anode is securely fastened in the anode holder by means of the chuck nut at the lower end of it, and the cathode is adjusted in its binding post in such a way that the propeller will revolve in the center of the cylinder.

Electrically, the anode holders and the binding posts for the cathodes are connected in series. Over each pair of electrodes there is a switch (see Fig. 3), by closing which it is possible to remove a completed determination without interrupting the current in any of the others.

The current for the analytical work is derived from the 220-volt lighting circuit. At the time the rotating apparatus was installed the laboratory happened to be using, for heating purposes, an electric hot plate, provided with two switches, for heat regulation. It was found that with one of these switches closed a current of 3 amps. could be obtained, or with the other, 5 amps., or with both closed, 8 amps. Since 3 and 5 amps. are suitable current strengths for electrolysis with rotating anodes, the hot plate was made to serve a second useful

for a conflict, as well as to furnish a means of increasing and decreasing the current by degrees, eight lamp sockets (the top row in Fig. 3) are connected in parallel with one another and in parallel with the hot plate. With one 10-c.p. and seven

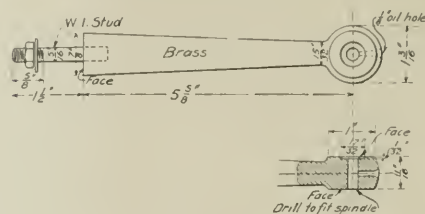


FIG. 4.—BRASS SUPPORTS.

32-c.p. lamps it is possible to obtain as much as 33 1/4 amps. without the aid of the hot plate (a cut-off switch for which has been provided). By means of lamps and hot plate combined one can regulate the current by steps of 1/4 amp. from 0.25 amp. to the highest current that is of practical use for this work.

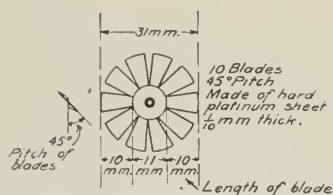
It is well known that any interruption of the electric current during electrochemical analysis casts doubt upon the accuracy of the work and always causes delay and annoyance. To shield the work on this apparatus from the whims of circuit breakers—mechanical and human—an automatic switch has been installed, which, on the failure of the lighting circuit, immediately drops and connects a battery of storage cells with the electrolytic work.

The current from the storage battery is regulated by means of the lower row of lamps (Fig. 3). Upon the return of the 220-volt current the switch rises, automatically cutting out the storage cells and connecting the electrodes to the lighting circuit as before. The storage cells, while able to discharge at a rate of 3, or even 5 amps. for a short time, have not capacity enough to permit continued use at such a rate.

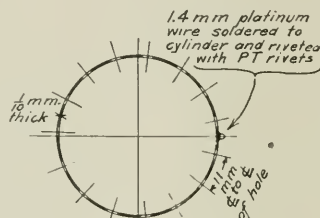
It may be remarked in passing that a third use has been found for the electric hot plate mentioned above. When not in use as a rheostat for the current going to the electrolytic apparatus, it can be used as a rheostat in charging the storage battery at an 8-amp. rate without interfering with its usefulness as a source of heat.

This somewhat complicated apparatus has been developed step by step from a modest beginning—a single jeweler's buffing spindle geared horizontally to a very large wheel, patiently turned by a very small boy. Various hands and minds have been concerned in the evolution, and thanks are

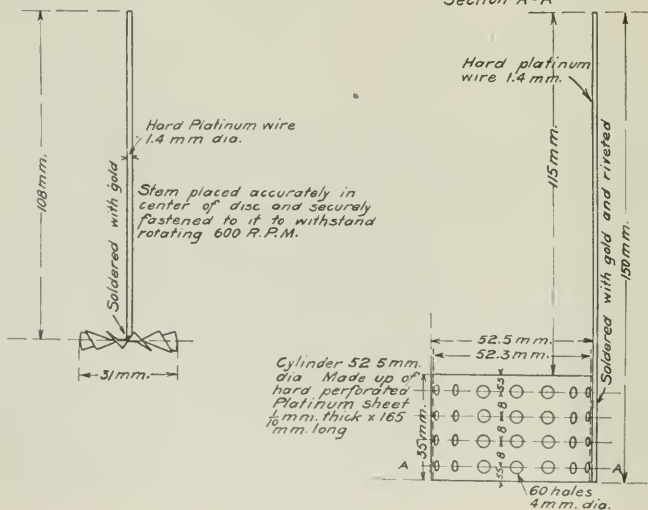
ANODE Made of Platinum Weight approx. 6 grams



CATHODE Made of Platinum Weight approx. 17 grams.



Section A-A



FIGS. 5 AND 6.—ANODE AND CATHODE.

purpose, and has been adopted as a rheostat for the current going to the electrolytic apparatus.

To open one of the switches of the hot plate, however, means less heat available from it, and at times when the full heat is required it is inconvenient to open a switch. In order to provide

due especially to W. K. Freudenberger, electrician, who devised the automatic switch and installed the intricate system of wiring for the switchboard. A second article will follow.

COPPERHILL, TENN.

Melting Iron in the Foundry Cupola.

BY PROF. H. McCORMACK.

The work described in the following pages was undertaken in the foundry of Armour Institute of Technology with the view of securing some data on cupola practice which would be of economic value.

For this experiment the melting was conducted, as has been customary, in this foundry.

The cupola is one made by the Whiting Foundry Equipment Company, size inner diameter, 0.565 m.; height of charge, 1.0 meter.

The blast is supplied by a motor-driven fan blower.

The charge for this heat consisted of 725.76 kilos of pig iron, 147.2 kilos of coke, and 45.36 kilos of limestone flux. It was charged as follows:

	Kilograms.
Bed charge of coke.....	99.8
Pig iron	272.2
Limestone	22.7
Coke	22.7
Pig iron	226.8
Coke	22.7
Limestone	22.7
Pig iron	226.8

The analysis of the—

	Graph. Carbon.	Comb. C.	Sulphur.	Phosphorus.	Manganese.	Silicon.
Pig iron.....	3.62	0.585	0.08	0.376	0.615	2.23
Cast iron produced.	2.63	0.86	0.08	0.535	0.464	2.11

The coke analyzed: Ash, 13.08; sulphur, 2.15; phosphorus, 0.212.

Blast Data.—The blast pressure was 1.2 inches of water = .071 oz. = 2.40 gm. The blast velocity was taken by means of a Pitot tube attached to a differential gauge, and was found to be 2 g. $\times$ 81.7 or 72.5 ft. per second = 22.09 meter per second.

Area of blast pipe = 0.02136 sq. meters.

Volumes of air delivered = $22.09 \times 0.02136 = 0.4718$ cu. meters per second.

Volume corrected for pressure = .47295 cu. meters.

Volume of air delivered per minute = $60 \times 0.47295 = 28.377$ cu. meters.

The temperatures were taken of the escaping gases with a Whipple temperature indicator, and of the metal and slag with a Fery radiation pyrometer. Temperature of the room 23° C. The blast was turned on at 2.56 and the temperature taken then and at subsequent intervals as follows:

Time	2:56	2:59	3:00	3:11:30	3:2:30	3:3:30	3:4
Temperature, C....	105°	250°	282°	372°	465°	480°	545°
Time	3:5	3:6	3:10	3:23	3:27	3:30	3:35
Temperature, C....	665°	760°	851°	945°	1090°	1260°	1275°

The blast was shut off and the bottom dropped at 3:35.

The amount of slag was 58.9 kilograms.

Amount of coke in bottom drop, 2.2 kilos.

The slag was very dark in color, showing an excess of iron.

The cast iron produced was of good quality, poured and machined well.

It gave tension tests of 33,100 pounds per square inch, and 31,900 pounds per square inch.

Transverse tests of 1,460.00 pounds per square inch and 1,461.60 pounds per square inch.

The calorific value of the coke was determined in the Parr calorimeter and found to be 3,218.5 calories.

Heat lost in the escaping gases:

The melting lasted 39 minutes.

28,377 cu. meters of air were supplied per minute.

$39 \times 34.02 = 1,104.5$ cu. meters of air supplied during the melting.

1 cu. meter of dry air weighs 1.2923 kgm.

$28.377 \times 1.2923 = 36.67$ kilo of air per minute.

Specific heat of air = 0.2374.

$0.2374 \times 36.67 = 8.7055$ calories per minute to raise the air 1° C.

Average temperature 1st 6 minutes, 444° C.

$8.7055 \times 6 \times 444 \dots\dots\dots 23,191.4$

Average temp. 6th to 12th minute, 615° C.

$8.7055 \times 6 \times 615 \dots\dots\dots 32,123.3$

Average temp. 12th to 24th minute, 916° C.

$8.7055 \times 12 \times 916 \dots\dots\dots 95,690.8$

Average temp. 24th to 33d minute, 1,035° C.

$8.7055 \times 9 \times 1,035 \dots\dots\dots 81,091.7$

Average temp. 33d to 39th minute, 1,200° C.

$8.7055 \times 6 \times 1,200 \dots\dots\dots 62,679.6$

Total to heat air for 39 minutes..... 295,576.8

Calories to melt iron and raise its temperature:

Weight of iron..... 725.76 ko.

Specific heat of iron..... 9.1124

Latent heat of fusion..... 33.0

Melting point (LeChatelier)..... 1,220° C.

Temperature of iron coming from the cupola, as taken by pyrometer, 1,275° C.

$725.76 \times .1124 \times 1,220 = 99,523.47$ calories to raise to melting point.

$725.76 \times .33 = 23,950$ to melt.

$725.76 \times .1124 \times .55 = 448.66$ to raise melted iron to 1,275° C.

Total calories applied to iron = 123,922.1.

Calories used in slag formation:

To change CaCO_3 to CaO 167.68 cal. per kilo.

$45.36 \times 167.68 = 7,605.96$ calories.

Amount of slag, 35.5 kilograms.

550 calories are required per kilogram for slag fusion (Richards).

$35.5 \times 550 = 19,525$ calories.

$19,525 + 7,605.96 = 27,130.96$ calories applied to slag.

Calories to heat fire brick of cupola:

Inner diameter, 0.565 m.

Height of fusion zone, 1.00 m.

Brick have thickness of 0.11 meter.

$.565 \times 1.0 \times .11 = .06215$ cubic meters of fire brick to be heated by coke.

Specific gravity of brick = 2.2.

$2.2 \times .06215 \times 1,000 = 136.73$ kilos of fire brick.

Specific heat of fire brick, 0.26.

Assume 800° C. as the average temperature of the fire brick, then:

$136.73 \times 0.26 \times 800 = 28,440$ calories to heat fire brick.

Summary:

Calories to heat air..... 295,576.8

" " heat and melt iron... 123,922.1

" " form and heat slag... 27,130.9

" " heat cupola brick... 28,440.0

" for radiation (by difference) 39,990.5

Total 515,060.3

Per Cent.

57.3

24.1

5.3

5.5

7.8

100.0

Calories from the coke:

Assume to have 2.2 ko. in bottom drop leaves 145.0 kilo consumed in cupola.

$$3,218.5 \times 145 = 466,682 \text{ calories.}$$

Calories from oxidation of carbon and silicon in the pig iron.

Carbon:

	Per Cent.
Loss of carbon	
Total carbon in charged iron.....	4.205
Total carbon in cast iron.....	3.490

Carbon oxidized..... 0.715

$$.715 \times 725.76$$

100

Calories, carbon oxidized to $\text{CO}_2 = 8,080$.

$$5.189 \times 8,080 = 41,927.1 \text{ calories.}$$

Silicon:

	Per Cent.
Loss of silicon—	
Silicon in charged iron.....	2.23
Silicon in cast iron.....	2.11

Silicon oxidized 0.12

$$.12 \times 725.76$$

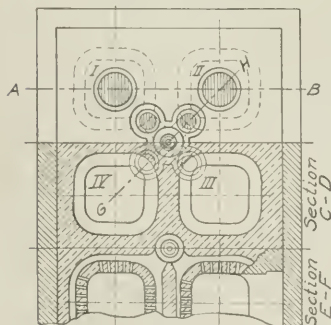
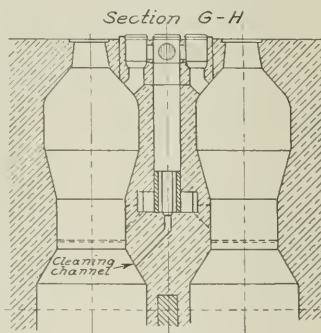
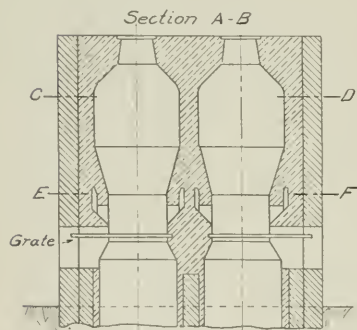
100

Calories, silicon to silicon dioxide, 7,407.

$$7,407 \times .871 = 6,451.2 \text{ calories.}$$

Summary of calories developed:

From coke	466,682.
" carbon of iron.....	41,927.1
" silicon of iron.....	6,451.2
Total	515,060.3



FIGS 1 TO 3.—SECTIONS OF RING PRODUCER.

The slag from this heat was unsatisfactory, being dark and viscid. Calculation also shows a deficiency of calcium oxide. The amount of heat consumed in heating the air seems excessive. In view of these facts, it was decided to run the next heats with less volume of air and with a higher ratio of flux. The gases escaped from the cupola at an excessively high temperature, the greater part of the time being above $1,000^{\circ} \text{C}$. This could be materially lowered if more metal was to be melted, so that the escaping gases could be utilized in heating the charge, and shows that there is fuel economy in melting over a long period in a small cupola rather than for a short time in a large one, as the principal fuel loss is in the heat carried away in the escaping gases. Further experiments are being conducted along these lines. I am indebted to Mr. Agle, shop superintendent, and to Mr. Howell, foundry foreman, for the very great assistance they have rendered in carrying out these tests.

Laboratory of Armour Institute of Technology, Chicago.

The Jahns System of Transforming Solid Fuel into Gas.

BY OSKAR NAGEL, PH. D.

There can be no doubt that as soon as the common fuel used at present for generating steam in our industrial plants can be transformed by a simple process into gas, which can be used for both fuel and power purposes, a wide field of application will be opened for producer gas.

The Jahns ring producer is accomplishing these results. A number of these producers are now in operation and giving the best of satisfaction at several German and Belgian coal mines. In these producers the lowest grade of bituminous coal, sometimes containing not over 25 to 30 per cent of carbon, is gasified without any difficulty from clinking or tar.

The main feature of the Jahns system is that no fuel is charged into the producer during the time of gasification, and that a number of producers is connected by means of channels to one unit.

The individual producers of the total unit are charged at certain intervals after each other, ignited, gasified without recharging, disconnected, discharged, recharged and reconnected. The tarry gases of the

younger producers are drawn through the oldest producer. The necessary combustion air is simultaneously drawn in at the bottom of the producers. At the time when the youngest producer is ignited, the oldest is in full incandescence and the upper part of its content is—by the influence of the heat of the lower part and of the connected producers—coked to such an extent that the combustion of the upper layer will furnish gas free of tar.

If now during this period the gas of all the younger producers is drawn through the oldest, all the gas leaving the system will be free of tar. When the oldest producer is burnt out it is disconnected or, if it is not burnt out perfectly, connected with the next younger producer, through which now all the gases are drawn. During this period the upper layer of this producer is sufficiently coked and free of tar.

The gas from such a system will be the purer, the greater the number of the individual producers contained in the unit.

The gas production is continuous; the burnt-out producers are disconnected without interfering with the others, and the gas production is not influenced by the removal of the clinkers.

Figs. 1 to 3 show a Jahns producer plant which is in operation at the coal mine Von der Heydt, near Saarbruecken, Germany.

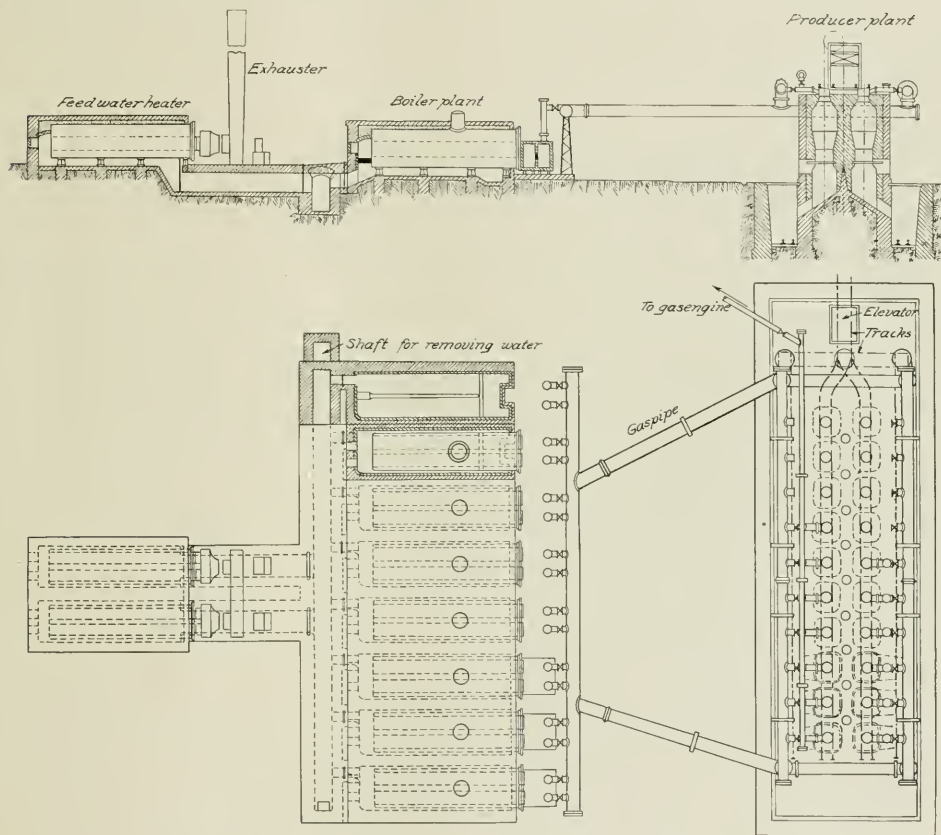
Each four producers have at the intersection of the separating walls a common vertical channel, with regulable openings into the same at the top and at the bottom. The main gas pipe is connected with an exhauster. The grate bars are removable, so that the ash can fall down. The ash pits are closed by means of doors.

When the first producer is being charged, its connections

the fourth producer is connected and ignited and the gases of the fourth, third and second producer are passing through the first producer. The latter has been burning now for about three-fourths of its period, is very hot and has its upper layer perfectly coked, being thereby enabled to liberate the passing gases from tar.

If the upper part of the charge is burnt out so far that the passing gases are not fixed any more, the gas-outlet valve and the lower valve of the second and the upper valve of the first producer are opened and the gas-outlet valve and lower valve of the first producer closed. The gases from the first, fourth and third producer now go through the second producer to the main gas pipe.

The first producer, after being completely burnt out, is dis-



FIGS. 4 AND 5.—ARRANGEMENT OF PRODUCER PLANT AND BOILER PLANT.

to the channel are closed and the connection to the gas main opened. The charge is ignited by a wood fire and slowly burnt. After about one-fourth of the burning period of this producer, the second producer is started, its ash door and the upper channel connection and the lower connection to the first producer opened. The gas from the producer II. now goes downward through the vertical channel, upward through producer I. and passes with the gases of the latter to the main gas pipe. As soon as the first producer is burnt down about one-half, the second about one-fourth, the third producer is ignited in the same manner and connected with the vertical channel.

The continuous gas production of the unit begins when

connected by closing the upper valve; the grate is drawn and the clinkers pushed into the ash pit. Then the bars are put back, the producer charged, ignited and by opening the upper valve connected again with the unit. The former part of the first producer is now taken by the second producer, which is continuing the production of fixed gas.

Each producer has a capacity of 4 to 5 tons. The fuel is charged into the producer by means of dump cars. The first ignition is effected by a wood fire and afterwards by the incandescent clinker contained in the ash pit. Gasification starts immediately after charging. The burning period of a producer charged with fuel containing about 75 per cent of carbon is 96 hours, charged with fuel containing 25 per cent

of carbon 48 hours. Perfect burning-out is effected by blowing steam into the producer after the gasifying period or by allowing the residuum to burn out perfectly in the ash pit, the gas formed thereby rising up into the producer.

The gas so obtained contains 7 to 9 per cent CO_2 , 16 to 20 per cent CO , 18 to 22 per cent H_2 , and 1 to 4 per cent CH_4 .

Any material containing carbon will furnish producer gas by means of this apparatus, no matter how high the content of ash or volatile substances. The percentage of tar in the gas produced is remarkably low, so that very little scrubbing is required to make it fit for the use in gas engines.

Smoke Abatement.

The Chamber of Commerce of Syracuse, N. Y., has just published a long report of 42 pages by its committee on smoke abatement. The chairman of the committee is Dr. JOHN A. MATTHEWS, of the Crucible Steel Co. of America, while the other members of the committee are Messrs. JOHN H. BARR (Smith Premier Typewriter Co.), W. H. BLAAUVELT (Semet-Solvay Co.), CARLETON A. CHASE (Syracuse Chilled Plow Co.), WILLIAM KENT (Syracuse University), J. D. PENNOCK (Solvay Process Co.) and JOHN E. SWEET (Straight Line Engine Co.). The report should attract attention far beyond Syracuse, not only on account of the concise and exact statement of the principles underlying perfect combustion and smoke abatement, but because these principles are explained in such clear language as to be understood by the general public. After various introductory notes the principles of combustion and the causes of smoke are summed up.

"When coke, which has its carbon in the form of fixed carbon, or anthracite coal, which contains only 5 or 6 per cent volatile matter, is burned on a boiler grate, the air drawn through the spaces between the lumps of fuel by natural draft readily brings about complete combustion of the fuel to carbonic acid gas; this proceeds with no difficulty and without smoke, provided an initial temperature of 700°C . ($1,300^\circ \text{F}$.) is furnished and an adequate supply of air passes through the bed of the fuel. With bituminous coal, however, containing 22 to 35 per cent volatile hydrocarbons, the process of combustion is quite different. Supposing the mass of fuel on the grate to be incandescent and a fresh charge of bituminous coal is made, what takes place?

"That portion of the coal next to the hot coals begins immediately to give off steam from the water in the coal and hydrocarbons follow and pass through the coat above, and are reduced in temperature; it is likely that the air at this time is insufficient on account of the choking of the pores in the fire-bed; or if there is air enough, it is too cold for ready combustion of the gases, or is imperfectly mixed; the hydrocarbon gases reach the cold boiler tubes, where they are further chilled and only partial combustion takes place; the carbon being precipitated in the form of soot, is carried along with the fire gases to the stack, and is expelled as black smoke. Complete combustion of these hydrocarbons can be effected only under the following conditions:

"First, a temperature sufficiently high, about 670°C . ($1,240^\circ \text{F}$.), to bring about instant ignition of the gases; second, a sufficient supply of air, preferably heated, to combine with the carbon and hydrogen of the gases, but not a large excess of same; third, a good mixture of the air and hydrocarbons. Unless these conditions are strictly observed only partial combustion will take place, and carbon will separate according to the following reaction of air upon methane, ethylene and acetylene, which are the principal gases evolved:



"Carbon, soot or smoke thus formed can be burned with

very great difficulty; its formation must be prevented. This is possible by increasing very largely the amount of fire-brick in the furnace, which, by its incandescence from heat stored up and a sufficient supply of air, will burn the gases without precipitating free carbon.

"To the inexperienced, heavy masses of black smoke indicate a large loss of fuel. The loss, however, is not as great as it would seem. At a large boiler plant in this vicinity careful tests of the carbon in smoky waste gases were made, which showed that the plant was losing not more than 1 per cent of the fuel value of the coal in the smoke itself, but at the same time the unburned gases may have caused great loss.

"While, undoubtedly, black smoke is injurious to the health of man and damages property of all kinds, there is in waste gases from factory chimneys still another ingredient which is also injurious to health and which cannot be eliminated, namely, sulphurous acid, formed during the combustion of coal. The bituminous coal for boilers may contain as high as 1.5 to 2 per cent of sulphur, which is converted into sulphuric acid by the process of combustion; while a small percentage of this is combined with ammonia, formed from the nitrogen of the coal, the major part escapes as acid into the air."

The direct cause of smoke thus is that the gases distilled from the coal are not completely burned in the furnace before coming in contact with the surface of the boiler, which chills them below the temperature of ignition. The quantity and density of smoke depend upon many variable causes. Anthracite coal produces no smoke under any conditions of furnace. Semi-bituminous, containing 12.5 to 25 per cent of volatile matter in the combustible part of the coal, will give off more or less smoke, depending on the conditions under which it is burned, and bituminous coal containing from 25 to 50 per cent of volatile matter will give off great quantities of smoke with all of the usual old-style furnaces, even with skillful firing, and this smoke can only be prevented by the use of special devices, together with proper methods of firing the fuel and of admission of air.

Smoke may be prevented from forming if each particle of smoky gas, as it is made by distillation from coal, is immediately mixed thoroughly with hot air, and even if smoke is formed by the absence of conditions for preventing it, it may afterwards be burned if it is thoroughly mixed with air at a sufficiently high temperature. It is easy to burn smoke when it is made in small quantities, but when made in great volumes it is difficult to get the hot air mixed with it unless special apparatus is used. In boiler firing the formation of smoke must be prevented, as the conditions do not permit of its being burned.

As to the possibilities of preventing smoke, the first is to obtain anthracite coal. If this is not commercially practicable then one should try to obtain, if possible, bituminous coal with the smallest amount of volatile matter. The following special remedies are discussed in detail:

(1) **Proper Hand Firing.**—The general opinion in Europe is that while the efficacy of many mechanical devices cannot be denied, yet skillful and careful stoking is of first importance. This means firemen must receive a proper training. There are schools for firemen in Europe. On the other hand, in view of the fact that in America no specific and uniform instruction is available for the firemen, the various mechanical devices appear to offer the greatest immediate relief in this country.

(2) **Steam Jets.**—"There are many forms of application of the steam jet to boilers. Sometimes the steam is applied below and sometimes above the grate. Below the grate the effect is perhaps slightly to increase the draft, but mainly to soften the clinkers. Above the grate the steam jet is essentially for the purpose of inducing a draft of air over the fire and to mix the air with the gases from the coal. The steam itself is not a source of any heat.

"Many devices for smoke prevention which are based on the use of the steam jet are of little value, and seem to be made only to sell. Others are carefully worked out in their details and are really of use, especially when properly applied to meet the special conditions, when combined with a device for automatically adjusting the supply of air to the volume of gases produced. Based on the fact that the volume of gases is great immediately after fresh coal is charged and slowly falls off until the next firing, these devices open a damper above the fire immediately after the closing of the fire-door, and by a dash-pot arrangement this damper is slowly closed, thereby regulating the supply of air between the maximum and minimum amount needed.

"A number of such devices are in successful use, and when properly applied and operated will prevent smoke. The cost of their installation is low compared with stokers, but they effect economy in coal consumption only to the extent to which they more perfectly burn the gases by the admission of neither too little nor too much air to meet the varying requirements of the fire." While such steam jet devices can prove effective in the reduction of the volume of smoke, yet they should not be expected to result in any considerable economy of fuel; "on the other hand, unless properly operated they are quite apt to increase the cost of operation."

(3) **Hawley Down-Draft Furnace.**—The principle utilized in the operation of this furnace is not unlike that of the under-feed stokers, inasmuch as the volatile hydrocarbons pass through the green fuel before reaching the combustion zone.

The result is that the volatile gases are intimately mixed with the supply air as they are distilled off and the conditions are favorable for complete combustion when these gases attain the ignition temperature. The Hawley down-draft furnace was described and illustrated in our Vol. IV, p. 177.

The report states that "plants of moderate capacity, too small to make the installation of mechanical stokers advisable, may quite effectively reduce the formation of smoke, and with good economy, by the use of down-draft furnace. This is particularly the case when the fuel is of a favorable quality, the draft is good and the demand for steam is such that the boilers are not necessarily forced at times much beyond their normal capacity." It is claimed by the makers of the Hawley down-draft furnace that it will save from 10 to 20 per cent in the fuel; that it will increase the boiler capacity and that it will reduce the smoke emitted 90 per cent.

(4) **Mechanical Stokers.**—There are four types of mechanical stokers. First, the forwardly inclined grate, of which the Roney stoker is an example. Second, the "V" shaped grate, of which the Murphy stoker is a representative. Third, the under-feed stoker. Fourth, the chain grate.

"From the point of view of smoke prevention the automatic stoker is merely a means for feeding the coal uniformly into the fire, and thereby maintaining uniform conditions, and therefore uniform production of hydrocarbon gases. Uniform conditions make it much easier to maintain perfect combustion of the hydrocarbons, and hence to prevent smoke, but very many installations of automatic stokers smoke very badly, oftentimes quite as badly as furnaces with poor hand-firing.

"In order to prevent smoke, it is quite as necessary to maintain the proper conditions for good combustion with stokers as without them. To insure these conditions, it is customary to build a fire-brick arch over the stoker, either in the shape of a 'Dutch oven' in front of the boiler setting, which is usually the better plan where room permits, or the arch is thrown across the fire-box between the fire and the boiler. It is usually quite difficult to maintain an arch in this position owing to the high temperature to which the brick work is subjected on both sides, and many devices have been put forward to maintain these arches. One type, which appears so far to be quite successful, consists of special shaped bricks, which are perforated so that air from the outside is permitted to

travel the whole length of the arch within the chambers or flues formed by these perforations, and is delivered, considerably heated, at the rear end of the arch, where it supplies the air for the final combustion of the gases. The heat absorbed by this air keeps the bricks sufficiently cool to prevent their destruction. The 'Dutch oven' construction has the advantage that this arch is free to radiate its heat through the top, and it is, therefore, relatively easy to maintain."

The use of mechanical stokers not only reduces the quantity of smoke emitted but effects a considerable saving over hand-firing, and "with large enough a plant a fair return on the investment for mechanical stokers can be reasonably expected."

But all devices to bring best results should be carefully handled. In some cases a bonus to the firemen has produced good results, but owing to the weakness of human nature the permanent effectiveness of such measure is somewhat doubtful. Continuous carbon-dioxide indicators have been used as a means of determining such a bonus, and in large plants these devices have produced good results.

The recommendation of the Committee as to the installation of smoke-abatement devices are three. First, the purchaser should put the burden of responsibility upon the firm installing the device. Second, the plans for new steam plants should be submitted to some competent authority for approval. Third, success in smoke prevention can only be obtained through the hearty co-operation of the coal users themselves, and this co-operation on the part of the owner of every steam plant is earnestly requested.

A circular letter sent by the Committee to manufacturers in different cities asked the questions whether the manufacturer considered that in making his installation of smoke-preventing devices he had made "a sacrifice to public sentiment." To this question thirty-two replied no, and of ten who said yes only five were using mechanical stokers. Another question was whether the manufacturer considered that "the good accomplished in smoke abatement is worth while the cost to manufacturers, hotels, etc." Thirty-two said yes, two said no and six were in doubt. The Committee considers this very strong evidence that the manufacturers themselves do not think that they have been oppressed. While the question of smoke abatement may be considered from the aesthetic standpoint, yet the economical point of view should be most strongly emphasized, and it should be clearly understood that in many cases it will be possible to solve the problem of smoke abatement with simultaneously improving the efficiency of operation.

The Detinning Suit.

It seems that the detinning suits are bound to become one of the most celebrated and complicated litigations on engineering matters ever witnessed in this country. On page 46 of our Vol. IV, we recorded the decision of the lower courts in the suit of the Vulcan Detinning Co. against the American Can Co. in favor of the latter, and on page 345 of our Vol. V, we recorded the decision of the higher court reversing the former decision.

In the meantime a suit has been begun by the firm of Theodor Goldschmidt, in Essen, Germany, against the Vulcan Detinning Co., asking the court to enjoin the latter company from operating their electrolytic detinning plants. It will be remembered that while the firm of Theodor Goldschmidt was no part in the first suit, the secret electrolytic detinning process invented by Dr. Hans Goldschmidt and the mode of importing the secret process to other countries are at the bottom of the whole controversy. The details will be found in our former articles referred to above. The suit was recently continued to Feb. 24.

The Goldschmidt Co. is represented by Mr. Halsey M. Barrett and Mr. Hubert E. Rogers, the Vulcan Co. by Messrs. McCarter and English.

The Manufacture of High-Grade Steel in the Electric Furnace.

The progress which electric refining of steel is making in Germany and the attention which it attracts is indicated by the fact that three different articles on this subject appeared during the month of November in *Stahl und Eisen*. An article by Prof. Wedding, the Nestor of German steel men, dealing with new developments of the induction furnace, is given elsewhere in this issue. In another very interesting article in *Stahl und Eisen*, Nov. 20 and 27, the problem of steel refining in general and in the Héroult furnace in particular is discussed by Director O. THALLNER, of Bismarckhütte, in Upper Silesia.

Mr. Thallner first discusses at great length the possibilities of producing high-grade steels in ordinary metallurgical furnaces. The following two general classes of processes have proven commercially successful. First, chemically very pure ores are treated and a chemically very pure and qualitatively very good pig iron is produced which is then treated to produce high-grade steel. Secondly, the starting material is of a less pure quality, which is treated by a combination process; either first in the puddling furnace and then in the crucible or open-hearth, or first in the converter and then in the open-hearth and perhaps also in the crucible.

Processes belonging to the first kind are very much more expensive than those belonging to the second kind. Nevertheless the former processes have held their own, although the products of both kinds of processes, according to their chemical analysis, are often claimed to be of equal excellence. In view of the price difference of the products it must be concluded that there is a difference in quality. But then it is clear that chemical analysis, as now made, does not give conclusive evidence as to quality.

As to industrial analysis, all steel works determine phosphorus. Sulphur and copper are often determined, but not always. Arsenic is determined in few cases. When sulphur is determined, it is not determined whether it is dissolved or exists in combination with iron or copper or arsenic. But worst of all, industrial chemical analysis does not indicate the rôle which oxygen plays in steel; it does not state whether the oxygen, if determined, comes from a chemical compound with iron, or from a solution or emulsion or slag rest, or from included gas or oxides. Under these circumstances the determination of oxygen does not give any indication how deleterious its effect may be. There is very little known as to the soluble oxides, though it is known that dissolved oxides are a very important factor in determining the quality of the product. This is especially the case with respect to the formation of blow-holes and pipes.

Mr. Thallner produces considerable evidence to show that dissolved ferrous oxide, the chief carrier of hydrogen, very considerably increases the alloying capacity of the iron with hydrogen. The surest means to prevent the deleterious effect of hydrogen on blow-hole formation is thorough deoxidation.

Mr. Thallner then refers to Braune's investigation of the influence of nitrogen in iron (our Vol. V., p. 51). He does not agree with Braune's conclusions, since Braune treated his steel in an atmosphere of ammonia, not of pure nitrogen; hence he had both hydrogen and nitrogen. Mr. Thallner produces some evidence to prove his conclusion that if we deoxidize the bath by means of carbon, then the escaping carbon monoxide gas also removes the nitrogen.

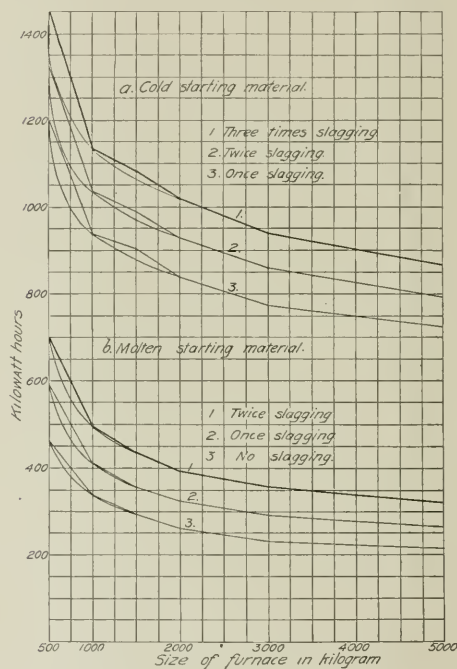
The net result of the general discussion of Mr. Thallner is that it is of chief importance for progress in steel manufacture to remove completely all deleterious impurities, and that a very important step in the right direction will have been accomplished, if we can do this with sulphur, slags and oxides.

As long as we know as little as we do now concerning the physics of the problem (structure, etc.) the only way to make further progress is to produce a chemically absolutely pure

material. The purer chemically a product is the higher its quality. But the determination of chemical purity must not be restricted to the determination of phosphorus, sulphur, arsenic and copper, but must be broader, and special attention must be paid to the oxides.

In passing over to a discussion of the electric steel furnace, Mr. Thallner remarks that the electric furnace has often been compared in the past with the crucible furnace, and has been considered simply as a melting furnace. But there is a great difference between these two types of furnaces. As used heretofore the electric furnace, with its basic lining, is simply a basic furnace for smelting under absence of fire gases but not under absence of air. The chemical processes in it are different from those in the acid crucible, since in the electric furnace there is no silica nor its gradual solution, reduction and the continuous effect of the silicon on the deoxidation under absence of air.

If in a crucible furnace the crucible would be used without a



ENERGY CONSUMPTION IN HEROULT STEEL FURNACE.

cover, it would be simply an imitation of the acid open-hearth furnace, and it would be necessary to employ a slag in order to protect the metal from the direct influence of the fire gases. But then we would have the disadvantage that the ferrous oxide in the slag would be oxidized to ferro-ferric oxide, and would then be able to give off oxygen to the metallic bath. Then we would lose the principal characteristics of the crucible process, namely, the long lasting period in which the metal is left at rest, with simultaneous mechanical removal of the oxides, their reduction in the metal by silicon and the simultaneous removal of gases. This process cannot be obtained in the basic open-hearth furnace nor in the acid open-hearth furnace nor in the electric furnace, nor would it be possible in the basic crucible.

The electric furnace is, therefore, different from the crucible furnace and must be considered as a distinct apparatus.

Further, the electric current should be considered simply as a source of heat, though as a very clean and easy source of heat. It had been thought that the electric current would have a direct desulphurizing effect, since it permits to keep the metal for any length of time at a high temperature. It is true that sulphur is able to migrate and is easily oxidized and can be removed by heating, roasting, etc., if it is present in large quantities, but it is impossible to go in this way below a certain limit. For this reason it is difficult in the open-hearth furnace to fix the moment at which the desulphurization is complete. It is possible only by repeated renewal of the slag, the fresh slag added being free from sulphur.

If at any stage of the open-hearth process a few tenths of a per cent of tungsten or molybdenum are added to the bath, the content of sulphur will decrease considerably, but also the content of these metals. As soon as they disappear the content of sulphur increases again. Tungsten and molybdenum are strong desulphurizers also in the crucible. The desulphurizing action is due to the fact that their oxides are able to combine with the sulphur, so that these oxides with the sulphur pass into the slag. The oxides are not reducible therefrom, but evaporate. The iron oxides of the slag do not evaporate, they combine eagerly with the sulphur and phosphorus, and the latter participate in any reduction process which removes iron from the slag. With respect to sulphur it must therefore be said that it cannot be removed by long heating with a slag rich in iron, because the latter prevents the diffusion of the sulphur into the iron.

To desulphurize, it is necessary to have a slag free from iron. Since a slag free from iron cannot be maintained continually in the open-hearth furnace, it is difficult to remove the sulphur with certainty by means of a slag as long as it is rich in iron, since it also absorbs eagerly sulphur from the fire gases, and this sulphur is brought back into the bath by any reduction process.

It is, therefore, clear that to desulphurize the presence of a slag free from iron is of chief importance. The possibility of thorough refining of steel in the electric furnace essentially rests in the possibility of completely mastering the slag composition and formation in the electric furnace, for the purpose of obtaining absolute chemical purity.

"The recognition of this fact is to be placed to the credit of the three men—Héroult, Eichhoff, Lindenberg—and their work should not simply be recognized but should be praised openly as great, important and obtained by persistent effort." With respect to controlling the slag, Mr. Thallner thinks the electrode furnace, and especially the Héroult furnace, to be specially suitable, because there is here the possibility of concentrating the maximum energy of electrical heat within the slag. Not even calcium resists the temperature of the arc, and it is possible to produce here very fluid and highly basic slags, as is hardly possible in any other process.

The process in the Héroult furnace consists essentially of three stages. In the first stage the phosphorus is removed, the conditions being about the same as in the open-hearth furnace, although far more favorable. At the same time the sulphur is considerably reduced, but not nearly to the same degree as the phosphorus. Further, the content of carbon decreases below 0.10 per cent. Manganese and silicon are also almost completely removed. This first stage shows the phenomena of over-oxidation.

The second stage is deoxidation. Mr. Thallner remarks that he is not permitted to describe this stage, which is *per se* only an acceleration of deoxidation under absence or without use of manganese and silicon. This stage is preparatory for the third stage.

The third stage is the reduction process. The object is to deoxidize the slag by formation of calcium carbide and silicon carbide, to reduce the iron from the slag and to keep the slag free from iron so as to make it permeable for the sulphur. In this period the desulphurization takes place with greatest

certainty and quickly down to practical trace. But a second effect is also obtained, because on account of the possibility of lengthening the period of melting we can get free from the slag emulsions, while new oxygen cannot come from the air into the bath, as the content of iron in the slag is continually reduced. The traces of sulphur which are simultaneously reduced are enabled to migrate again outwards and in connection with the calcium to evaporate and to be oxidized by the air. Naturally in this stage of greatest freedom from oxides, the addition of carbon may be carried out without reducing deleterious constituents of the slag. The steel can be finished free from oxides.

"The advantages of this metallurgical process may be simply summed up as the following three effects: First, dephosphorization; second, desulphurization; third, deoxidation to a degree which is never possible with the same amount of certainty in other processes using equally impure starting materials. This is an established fact and represents a progress the importance of which should not be under estimated."

Of course, the process requires careful work and extra cost, and the author warns optimists from thinking that they can now produce and sell high-quality steels without paying for it.

The first 1.5-ton Héroult furnace in the Lindenberg works in Remscheid has stood 2337 charges (between four and ten a day), cold and molten charges alternating irregularly and intermittently, and according to Mr. Lindenberg no essential repairs have become necessary. The slag does not attack the furnace. When the furnace has been emptied it is at once ready again for a new charge. Small repairs, if necessary, require neither considerable time nor great expense. The operation of the Héroult furnace requires more conscientious attendance than hard work. The accompanying diagram shows the consumption of energy when starting with cold and with molten metal. The curves give the consumption of energy in kilowatt-hours per ton of steel for different sizes of the furnace.

Other diagrams given by the author on the basis of 307 charges with molten metal and forty charges with cold metal, show that in practical operation the certainty with which the impurities can be held below predetermined limits is very great.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From our Special Correspondent.)

THE UNAUTHORIZED USE OF SCIENTIFIC PUBLICATIONS AND THE ABUSE OF PROFESSIONAL REPORTS.

A recent unauthorized use of the proceedings of the Institution of Mining and Metallurgy has evoked a stern reminder that use shall not be made "of the discussions on papers or other subjects at the meetings of the Institution, in prospectuses or any other documents published in connection with commercial undertakings, without the written authority of the Council, and of each individual speaker or writer concerned previously obtained."

It is a regrettable fact that in only too many cases technical papers are written which have as a reason for their appearance some ulterior commercial objects. New processes must, of course, be described and discussed, but the greatest care should be taken that no written law or unwritten law of etiquette should be violated.

Of greater importance than this is the frequent abuse of technical reports, and the Council therefore consider "that all members should insist upon their reports and other documents connected with commercial undertakings, whenever published: (1) being distinctly dated; (2) being published *in*

extenso, or (3) if summarized, the summary to be approved and signed by the member concerned.

This valuable rule may well be commended to other than metallurgists. It is only too frequent that the honesty of a detailed report is rendered of no avail because of the selection and publication of isolated statements by interested parties.

THE EXACT MEANING OF TECHNICAL TERMS USED IN METALLURGICAL WORK.

The Council of the Institution of Mining and Metallurgy is to be congratulated on their bold stand regarding the manner in which certain technical terms should be used. As regards a great many estimates and measurements, it cannot be said in the words of one of Mr. Kipling's rhymes "There are nine and sixty ways * * * and every blessed one of them is right." Upon the subject of the term "ore in sight" so prominent in mining prospectuses and in reports from mine managers, the Council of the Institution of Mining and Metallurgy have come to the following wise decision:

"1. That members of the Institution should not make use of the term 'ore in sight' in their reports, without indicating, in the most explicit manner, the data upon which the estimate is based; and that it is most desirable that estimates should be illustrated by drawings.

"2. That as the term 'ore in sight' is frequently used to indicate two separate factors in an estimate, namely:

"(a) Ore blocked out—that is, ore exposed on at least three sides within reasonable distance of each other—and

"(b) Ore which may be reasonably assumed to exist though not actually 'blocked out,'

these two factors should, in all cases, be kept distinct, as (a) is governed by fixed rules, whilst (b) is dependant upon individual judgment and local experience.

"3. That in making use of the term 'ore in sight' an engineer should demonstrate that the ore so denominated is capable of being profitably extracted under the working conditions obtaining in the district.

"4. That all the members of the Institution be urged to protect the best interests of the profession by using their influence in every way possible to prevent and discourage the use of the term 'ore in sight' except as defined above; and the Council also strongly advise that no ambiguity or mystery in this connection should be tolerated, as they (the Council) consider that such ambiguity is an indication of dishonesty or incompetence."

The Institution have also adopted some definitions of weights and measures. These were printed on page 512 of the December issue of *ELECTROCHEMICAL AND METALLURGICAL INDUSTRY*.

THE STANDARDIZATION OF SCREENS.

The Institution of Mining and Metallurgy issued, in their November Bulletin, a report on the standardization of screens by Mr. Walter McDermott (who acted as chairman of their mesh standardization committee), and also a list of I. M. M. standard laboratory screens for use in making grading tests and for the correlation of screens used in commercial or other work. (These were printed on page 512 of the December issue of *ELECTROCHEMICAL AND METALLURGICAL INDUSTRY*.)

The Council decided that the only practical improvement on existing conditions would be the establishment of a standard set of laboratory screens, obtainable by all engineers, to be based on a uniform proportion between the number of meshes and the size of aperture, so that the great convenience of description by mesh could be retained, with a recognized equivalence of aperture.

A great deal of consideration was given, first to the relative sizes of wire and aperture to be adopted; and second to the number of screens which should be included in the standard table. On the first point a number of makers of wire cloth

were consulted; and it was decided that the adoption of equal size of wire and aperture would, in the majority of sizes, give the best screen, having the minimum tendency to shifting of the wires, and giving apertures corresponding fairly well with some of the similar mesh screens already in use in laboratories.

As regards the number of standards, the Council had to choose from a great variety of suggestions. Some engineers, recognizing the disadvantages of unnecessary refinements, advocated a small number of screens; while others were in favor of a long list, from which an engineer could select his own. The table which has now been accepted is a compromise between the extreme views.

To those who would prefer to see a greater number of sizes, it may be pointed out that not only does the manufacture of a large number of standards itself create an objection, but the introduction of unnecessary refinements in sizing by screens is not justified by the real accuracy of the process. Variations in ores, in methods of crushing, and in the personal equation, combined with irregularities, even in the most careful weaving of the cloth, all destroy actual accuracy; and in addition to this, excessive refinements in sizing are impossible in practical working of ore, and are not required therefore in the laboratory. If an engineer desires to use some special screen for reasons of his own, and if he describes it by the size of aperture, it will be easy to note its relation to the standard sizes of the table, by its position between two of these sizes.

In the preparation of the standard I. M. M. screens, the Council, recognizing the importance of reducing to a minimum the irregularities in manufacture above referred to, and knowing that a number of makers could not be expected to take the necessary precautions in the preparation of the small quantities of screening required for merely laboratory purposes, decided that it was advisable to get a good stock manufactured at one time by one maker, with one drawing of wires to the required gauges.

This has been now in part carried out, and means will be taken to supply all makers of wire cloth and dealers in laboratory equipment, with any number of sets of the cloth in squares of 8 in. or made up in nesting frames clearly marked with the mesh number, and the size of aperture in decimals of in. and mm. Enlarged photographs of some of the first sample sizes submitted are very satisfactory as regards the limited irregularity of the openings compared with ordinary commercial wire cloth; and thus, incidentally to the main object of uniformity of practice, an increased degree of accuracy of sizing will probably be secured.

WEAR AND TEAR IN ELECTRIC FURNACES.

A short note in the current number of the *Electrical Review* gives some information of a kind badly needed in regard to electric furnaces. At the beginning of last July the 1,500 kilogramme Heroult electric furnace employed at Lindenberg's steel works, in Remscheid, turned out its 2,000th charge. The furnace has been at work continuously since March, 1906, treating a charge previously melted in a Siemens-Martin metallurgical furnace. The dolomite bed of the Heroult furnace was repaired after every charge, but in other respects the furnace has lasted well, requiring only a new cover made of silicious material once every three to seven weeks.

THE FINANCES OF THE CASTNER-KELLNER ALKALI CO., LTD.

The shareholders in this undertaking are certainly situated more fortunately than those in the Electrolytic Alkali Co. which works the Hargreaves-Bird patents, whose disappointments I chronicled last month. The net profits of the Castner-Kellner undertaking for the year ended Sept. 30, after the usual expenditure in maintaining works, plant and machinery, was £116,754.11.5, which with £14,773.6.1 brought forward, makes £131,527.17.6. Debenture and other interests absorbed £9,697.8.2, and the interim dividend at the rate of £8 per

cent for the six months ended March 31, £18,000, leaving £103,830.9.4. The directors recommend that £30,000 be placed to depreciation reserve, writing £15,910 off plant and machinery and £7,500 off suspense account, the payment of £36,000 in dividends for the six months ended Sept. 30, making 12 per cent for the year, and leaving £14,420.0.4 to be carried forward.

MARKET PRICES DURING NOVEMBER.

The price of tin at the beginning of the month was £146.10 per ton, it fell to £135.5 on the 7th, and rose to £142 on the 12th, falling again to £134.10 on the 18th, slight irregularities occurred until £139 was reached on the 25th.

Lead opened at £18.18, and after varying from this value to £18.10 up to about the middle of the month, fell continuously, reaching about £18 at the end of the month.

The price of copper on Nov. 1st was £68 per ton, this being the highest price reached for some days. It fell to £59 on the 8th, rose to £61 on the 11th, fell to £59 on the 13th,

followed by some irregularities until the 20th, when it stood at £58, reaching £62 on the 25th, and closing at from £63 to £64.

Cleveland pig iron was 51/- per ton on the 1st Nov., it fell to 49/3 on the 5th, and rising with slight irregularities to 51/- again on the 14th, dipping to 50/3 on the 19th, rising to 51/- again on the 20th, fell to 49/10 on the 22d, where it remained until the 26th.

Hematite was 70/10 per ton on the 1st November, it fell irregularly to 68/- on the 8th, at which price it remained until the 11th, thus rising slightly with a few irregularities, and finally falling to 67/10 on the 27th.

The price of antimony at the end of the month was £36 to £38 per ton.

Copper sulphate was £23.10 per ton; ammonia sulphate, £12.5 per ton; bleaching powder thirty-five per cent, £4.10 per ton; white caustic soda seventy-seven per cent, £11.26 per ton, and shellac £11 per cwt.

London, Dec. 7, 1907.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

IRON AND STEEL.

Electrolytic Manufacture.—G. Hofer, in *Giesserei-Zeitung*, 1907, page 140 (*Revue de Metallurgie*, November), describes a process for producing pure iron, or pure manganese, or alloys of these metals. The oxides are soluble in melted calcium fluoride; such a solution, with the addition of more fusible fluorides, is electrolyzed, using enough current to keep the bath melted and also the deposited metals. More oxide is added as the bath needs replenishing. Carbon anodes are used, and loss of metal by volatilization is avoided, because it rests as a melted cathode at the bottom of the bath. Silica present is reduced, and the silicon escapes as fluoride, SiF_4 ; phosphorus is also volatilized. Ores rich in silica and phosphorus may thus be utilized. To economize on current, mixtures of oxides and reducing carbon should be made, so as to diminish the current required. Without such a suggested scheme, the cost of current for pure electrolysis would be prohibitory; with such a scheme the whole project reduces itself to a simple electric furnace reduction of iron ores, using a fluoride of calcium flux.

Chromium Tool Steel.—Léon Guillet has recently examined a new tool steel accidentally made in the electric furnace by adding double the charge of chromium intended. The data are given in *Revue de Metallurgie* for November. The analysis showed C 2.18, Cr 14.88, Mn 0.71 and Si 0.19 per cent. The normal steel was found under the microscope to consist of perlite with a double carbide of iron and chromium, the latter in sort of fibers. It cannot be rolled, and can be forged only with difficulty. It casts into clean ingots. To fit for use it is heated to 950°, cooled in air to 850° and then quenched in oil, when intended to cut steel; when to be used for cutting cast iron, it is heated to 1,050°, cooled in air to 950° and then quenched in oil. These tools give remarkable service, particularly in planers, being only slightly inferior to the expensive rapid tool steels containing tungsten or molybdenum.

Hardness of Tool Steels.—M. Demozay, in *Revue de Metallurgie* for September, contributes a study of the hardness of tool steels of the following percentage compositions:

No.	C.	Cr.	W.
1	1.5	2.5	...
5	2.0	...	6.0

No.	C.	Cr.	W.
6	0.5	1.5	10.0
7	0.5	3.5	12.0
10	0.6	2.8	8.0
11	0.7	3.8	7.8
12	0.9	6.0	22.0

The soft steels, slowly cooled, were heated to various temperatures and then quenched in water, oil or by air blast. The hardness was determined by the Guillery apparatus, using a sphere pressed into the test piece by 4 tons hydraulic pressure and measuring the diameter of the impression. A simple 1.1 per cent carbon steel has a maximum hardness when quenched in water at 850° C.; when quenched in oil it is nearly uniformly half as hard as water-quenched, but has a maximum hardness also at about 900°. Steels 6, 7, 10 and 11 showed maximum hardness when quenched at 1,200°; steel 5 is hard at starting, and becomes intensely so when quenched at 1,000°, the billet becoming warped and cracked.

Simple 0.9 per cent carbon steel was tested for its variation in hardness with temperature. It was found to get softer up to 100° C., then harder to about 250°, then uniformly softer as the temperature rises. Tempered chrome steel, with 2 per cent chromium shows no such minimum or maximum, but gets uniformly softer as the temperature rises. At 450°, however, it is still harder than the plain 0.9 carbon steel is at zero. Mushet steel, specially treated, is as hard to start with as chrome steel, rapidly softens until only half as hard at 100°, then as rapidly increases in hardness, until at 250° it is about equal to its hardness at 50°; from 250° up to 500° its hardness is nearly constant, only slightly diminishing, and at 500° it is still as hard as the chrome steel at 250° to 350°. This behavior is a distinct peculiarity of mushet steel. This steel, if untreated, or if annealed, becomes distinctly harder at 100° to 150°, at 300° to 350° has about the same hardness as at 0°, and then slowly gets softer. The modern high-speed steels all become harder up to 250°, then slowly fall off, but at 400° are still nearly as hard as when cold; in fact, some retain this same hardness up to 500°. The curves and detailed data of the original paper are too extensive to be reproduced, but contain valuable information for steel makers and users.

COPPER.

Alloys with Cobalt.—The physical and mechanical properties of a few alloys of these metals have been studied by Berthier and Guillemin and Reichart, but N. Konstantinow is the first to study the field systematically. His paper is in *Revue de Metallurgie* for November. The electric conductivity of copper decreases rapidly and regularly with increase of cobalt up to 5 per cent, then falls regularly, but much more slowly, to a minimum at about 90 per cent cobalt; after this, as pure cobalt is approached, the conductivity rises regularly and rapidly. The author considers this as proving the existence of solid solutions at 5 per cent cobalt and 10 per cent cobalt, with mechanical mixtures of these with copper, cobalt or each other at other proportions.

In studying the fusing points, pure copper and cobalt, melting at 1,084° and 1,505°, respectively, were melted together in magnesia crucibles in an atmosphere of hydrogen or nitrogen, using a kryptol electric furnace. The fusing point of copper is raised with increase of cobalt up to 6.5 per cent, which appears to be the limit of solid solution of cobalt in copper, melting at 1,110°. The melting point then rises rapidly to 30 per cent cobalt at 1,370°; from here to 65 per cent cobalt the setting point is constant at 1,370°, with a lower arrest of temperature at 1,110°, showing these alloys to be simply mixtures of 35 per cent copper in solid solution in cobalt with 6.5 per cent cobalt in solid solution in copper. These alloys always form two layers of different composition if allowed to stand. Over 65 per cent cobalt the upper melting point rises rapidly to pure cobalt at 1,505°. Photomicrographs were made of polished sections etched by HCl for alloys rich in copper, or by FeCl₃ solution for alloys rich in cobalt. The alloys with 5 cobalt, 95 copper and 10 copper, 90 cobalt showed the best grain and looked like the best alloys.

ALLOYS.

Composition and Electromotive Force.—N. Pouchine, in *Revue de Metallurgie* for October, presents some deductions upon the constitution of alloys as determined by their electromotive force in solutions of acids or alkalis. The principle is employed of not reading momentary differences of potential but only those which are approached asymptotically after several hours observation. Under these conditions the constitution of the alloys tested is brought out very strikingly. The following is a summary of the results and conclusions: *Silver-selenium* measured against Ag in 1/1 N. AgNO₃ solution showed very plainly Ag⁺Se. *Silver-tellurium*, similarly tested, showed Ag⁺Te. *Copper-tellurium*, tested against Cu in 1/1 N. CuSO₄, shows evidence of both Cu⁺Te and CuTe, giving between their solid solutions. *Lead-tellurium*, examined in 1/1 N. PbNO₃ solution, shows the existence of PbTe, which gives solid solutions with Pb but not with Te. *Tin tellurium*, in 1/1 N. H₂SO₄ solution, the compound SnTe is found. No definite compounds were found in alloys containing *hij-bismuth* or *zinc-cadmium*. *Copper-zinc*, the curve was studied in 1/1 N. ZnSO₄ solution against Zn, and showed clearly and decisively the compounds Zn⁺Cu, Zn⁺Cu, ZnCu and ZnCu₂. These conclusions are different from those obtained by previous investigators, but the potential curves point clearly to their presence. *Zinc-silver*, in the same electrolyte, these showed Zn⁺Ag, Zn⁺Ag, Zn⁺Ag, ZnAg doubtful, ZnAg₂. *Zinc gold* similarly examined, these showed Zn⁺Au, Zn⁺Au, ZnAu and solid solutions between Zn⁺Au and Zn. *Copper-cadmium*, studied in both 1/1 N. CuSO₄ and 1/1 N. H₂SO₄, showed solid solutions of Cd and CdCu, CdCu, solid solutions of CdCu and Cu. *Copper-tin*, in 1/1 N. H₂SO₄, showed clearly SnCu⁺ and SnCu₂, but no sign of CuSn, which was said to exist by Heycock and Neville. *Silver-tin*, similarly tested, showed only SnAg⁺. *Copper-silver-tin* in the same electrolyte, it appears that in Ag⁺Sn or Cu⁺Sn the copper and silver can mutually replace each other without destroying the identity of the alloy; it appears that there may exist in these alloys, Cu⁺Sn, Cu⁺AgSn, CuAg⁺Sn and Ag⁺Sn.

Gold-tin in 1/1 N. H₂SO₄ shows the existence of Sn⁺Au and SnAu, with solid solutions between Sn and Sn⁺Au. *Copper-aluminium* shows the existence of AlCu only. *Aluminium-silver* shows only AlAg. *Antimony-bismuth* shows a series of isomorphous mixtures in 1/1 N. KOH. *Antimony-zinc* shows only ZnSb⁺ and ZnSb, with no solid solutions in the system. *Tin-arsenic* in 1/1 N. H₂SO₄ shows very clearly SnAs⁺ and SnAs, analogous to the preceding alloys. *Tin-antimony*, tested in normal SnCl₂, H₂SO₄ and KOH, showed in all cases SnSb only. *Silver-antimony* in 1/1 N. KOH shows Ag⁺Sb and Ag⁺Sb. *Nickel-antimony* in 1/1 N. KOH shows Ni⁺Sb and NiSb. Alloys of lead with Cu, Ag, Bi, Sb and As showed no definite compounds or combinations; solid solutions were found only in the lead-antimony alloys. *Tin-nickel*, tested in normal SnCl₂, H₂SO₄ and KOH solutions showed only SnNi. *Tin-cobalt*, similarly tested, showed SnCo. *Tin-manganese* in 1/1 N. KOH gave only one compound, SnMn⁺. *Tin-iron* in the same solution gives clearly SnFe⁺ and no other compound. *Tin-chromium* shows neither compound nor solid solutions.

ALUMINIUM.

Aluminium.—F. G. A. Wilm claims, according to the *Brass World* of November, to be able to increase the strength and ductility of aluminium by chilling. In order to produce satisfactory results the aluminium, or the aluminium-copper alloy, must be chilled at a temperature between that at which the alloy becomes solid and a point not more than 30° below the recalescence point. When this temperature is reached the alloy is immediately chilled in cold water. The recalescence point was determined for copper aluminium alloys with various percentages of copper. For 1 per cent Cu it is 485° C., for 2 per cent 501° C., for 3 per cent 512° C., for 4 per cent 524° C., for 6 per cent 530° C., for 10 per cent 535° C., for 15 per cent 538° C., and for 33 per cent 540° C. For example, in case of an alloy of aluminium containing 4 per cent of copper, the point of solidification is 640° C., while the recalescence temperature is 525° C. The point at which the alloy must be heated previous to chilling, therefore, lies between 495° and 640° C.; by applying the method to this alloy cast in a chill mold the tensile strength was increased 48 per cent and the elongation 2 per cent. With sand castings nearly the same increase was found, and with wire sheet and rod the method likewise produced the same results.

SILVER.

Silver from Silver Chloride.—An anonymous writer in the *Brass World* of October has used the soda-ash method, but has abandoned it on account of the corrosive action of the soda-ash on the crucible and the frothing of the mass. He now uses the method of reduction by iron with subsequent melting of the reduced spongy silver. The silver chloride is placed in a tub filled with dilute sulphuric acid and pieces of clear wrought iron (or of galvanized iron clippings) are brought in contact with it. Iron dissolves and the silver is deposited as a gray powder. It is dried and melted. In order to reduce any stray particles of chloride of silver that may have escaped reduction a small quantity of soda-ash is used in melting it.

CALCIUM.

Calcium Hydride as Reducing Agent.—Dr. F. M. Perkin and Mr. L. Pratt's Faraday Society paper, which was already briefly noticed in our last issue, dealt with the reduction of metallic oxides by calcium hydride.

When copper oxide is mixed with calcium hydride in proportions corresponding to $2\text{CuO} + \text{CaH}_2 = 2\text{Cu} + \text{CaO} + \text{H}_2\text{O}$, and ignited by means of a match, a vigorous reaction ensues, and volumes of steam are given off. On cooling a black mass is obtained, which on treatment disintegrates, owing to solution of calcium oxide, and metallic copper in a state of fine division is obtained. Pyrolusite, hematite and tin stone all behave in a similar manner. Zinc oxide appears not to be

reduced. Lead sulphide and antimony sulphide both react vigorously, and during the reaction the mixture swells up considerably, rising up out of the crucible in a cylindrical form. Very little metal is produced, the bulk of the product being a dark gray mass, which appears to be a compound of the metal with calcium and sulphur.

Borax and boric anhydride also react with calcium hydride when the mixture is strongly heated in the muffle furnace. Silica in the form of fine sand only reacts after prolonged heating, but reaction takes place more readily when kieselguhr is employed. Wolframite and rutile only react with difficulty.

Experiments were also tried with metallic calcium and wolframite. In this case a particularly vigorous reaction takes place, the tungsten being melted and being obtained on cooling as a hard regulus. The heat is so great that the calcium oxide is also melted. Rutile is also reduced by calcium; the reaction, however, is not so intense, and the titanium and calcium oxide are not fused.

The action of metallic calcium upon metallic chlorides was also studied. Manganese chloride and cadmium chloride are readily reduced. When metallic calcium and strontium chloride are mixed together in molecular proportions and ignited by heating in an iron crucible by means of the blow-pipe reaction ensues:



Very little metal, however, is obtained, probably owing to the formation of a sub-chloride, $\text{ClSr} = \text{CaCl}$. On adding two atoms of calcium the reaction is intensely vigorous, and the metal is obtained as a fused regulus. With barium chloride the reaction is less vigorous. With the alkali metals very vigorous reactions also take place.

MISCELLANEOUS.

Fluxes for Soft Metals.—A long illustrated article on the choice and use of fluxes for soft metals will be found in the November issue of the *Brass World*. The three principal soft metals are lead, tin and zinc. Various combinations of them are used in commerce, but what is said about the individual metals applies equally to the alloys. Mixtures in which there is considerable zinc, however, must be fluxed with sal-ammoniac in the same manner as pure zinc. The whole subject is summed up in the following table:

Metal.	Best Flux.
Tin	Tallow.
Lead	Rosin.
Solders	Rosin.
Lead alloys.....	Rosin.
Tin alloys.....	Rosin.
Zinc	Sal-ammonia.
Zinc alloys.....	Sal-ammonia.

In the case of tin or tin alloys, rosin will be found better than tallow for making solder or babbitt metal, but if tinning is to be done, tallow should be employed. The method of using fluxes on soft metal is as simple as it possibly could be. The rosin, sal-ammoniac or other flux is sprinkled upon the surface while the metal is melted. No more than is necessary to clean the metal is used. The liquid scum is then skimmed off.

The Platinum Group.—L. Holborn, in an address before the British Association (*Revue de Metallurgie*, November), discussed at length optical pyrometry, and gave as the results of his most recent optical measurements, based on the validity of Wien's law, the following:

Palladium	$1,585^\circ \pm 10^\circ$
Platinum	$1,790^\circ \pm 15^\circ$
Rhodium	$2,000^\circ \pm 20^\circ$
Iridium	$2,400^\circ \pm 25^\circ$

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

ELECTRIC FURNACES.

Electric Furnace.—G. Holmgren, 873,861, Dec. 17, 1907. Application filed March 6, 1907.

The design of the furnace is based on the principle of electric generators with revolving field system and stationary armature. A two-pole single-phase generator furnace is shown in Fig. 1 in vertical and horizontal section. "The furnace has a U-shaped upright armature core 1 around the vertical shanks, of which the melting bath 2 of the furnace forms two closed circuits communicating with each other. The rotatable field magnet 3 has a vertical shaft 4 and two poles of segmental shape corresponding to the shape of the pole surfaces of the

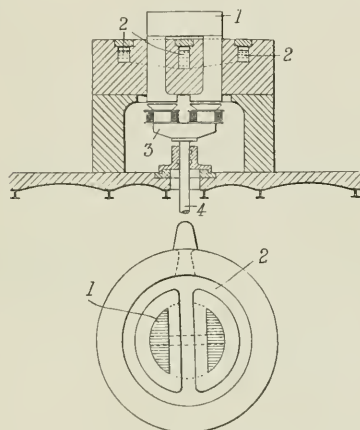


FIG. 1.—ELECTRIC FURNACE.

armature core. When the field magnet 3 is in the position shown in the illustration in relation to the armature core, the magnetic circuit is closed through both circuits of the melting bath. When the field magnet has been turned 90° from the said position, each half of the magnet circuit of the same is closed through one of the armature poles, so that the magnetic flux does not pass through the closed circuits formed by the melting bath. Nevertheless, it is possible, by giving the pole pieces suitable dimensions, to keep the total magnetic flux through the air gap between the field and armature cores substantially constant. The variation of the number of lines of force inducing the melting bath and of those short circuited by the pole pieces of the iron cores takes place successively, whereby vibrations in the iron cores will in a very high degree be avoided and the self-induction of the furnace will be comparatively low."

Refining of Steel.—G. O. Seward and F. von Kugelgen, 874,628, Dec. 24, 1907. Application filed July 6, 1907. Assigned to Virginia Laboratory Co.

The feature of the process is that no carbon electrodes are used, but the electrodes are pencils of the pig iron which is to be refined in contact with a proper slag. Pig iron is cast into blocks or into any suitable shape and two such electrodes are connected to the circuit. The heat is produced either by the resistance of the slag to the passage of the current, or by an arc between the metallic electrode and the slag or by a combination of both. The pencil melts off gradually and the metal collects at the bottom of the furnace, the refining being partly effected as the electrode melts, and partly as it lies at the bottom of the crucible under the refining slag. "The re-

fining effect is quick and complete, and no recarburization is possible. It is possible to use a much more oxidizing slag than would be possible with carbon pencils, because a slag containing a great deal of iron oxide would attack a carbon pencil seriously, but would have only a good effect in refining a metal pencil as it melted. It is also possible, as we have no carbon in the furnace, to introduce air as in the Bessemer process, and thus assist in burning out the impurities from the metal to be refined. A combination of Bessemer and electric effect is thus secured."

Tantalum.—M. von Pirani, 873,958, Dec. 17, 1907. Application filed March 18, 1907. Assigned to Siemens & Halske Co.

Homogeneous coherent bodies of tantalum can be produced by smelting in an electric arc furnace. The tantalum to be smelted is placed on the positive electrode. The furnace is exhausted. A long and powerful arc may be started in the vacuum without bringing the electrodes first in contact, if the residue of gas remains in the vacuum furnace is first ionized. The ionization is effected by a metallic oxide being placed in the furnace and heated. The oxide is preferably connected with the cathode and the heating is most simply effected by means of a platinum wire embedded in the oxide, and which is brought to incandescence by passing an electric current through it. Barium oxide is particularly suitable. With an interval between the electrodes of several centimeters and a tension of about 100 volts, an arc may be produced with a current of 50 amps. sufficient to melt the tantalum.

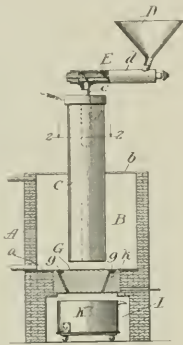


FIG. 2.—ELECTRIC FURNACE.

Electric Furnace.—William R. Parks, 873,890, Dec. 17, 1907. Application filed April 11, 1907.

The peculiarity of the furnace which is shown in Fig. 2 rests in the construction of the electrodes. C is a hollow tube electrode, the furnace charge passing from the hopper D through the hollow electrode downwards into the furnace. G is the other electrode, and has at its top a circular gutter g, in which the molten metal and slag collect and are drained off through several downwardly extending drain openings k into the fore-hearth K.

ELECTROLYTIC PROCESSES.

Copper from Sulphide Ores.—C. H. Ehrenfeld and J. R. Grove, 866,849, Sept. 24, 1907. Application filed Sept. 7, 1906.

To recover copper from copper sulphide ore, for instance, chalcocypite, the ore is pulverized to about 30 mesh; it is heated in an atmosphere with a limited supply of oxygen for the purpose of expelling the sulphur and of converting the metalliferous substances of the ore into the lower oxides of the metal. The copper is then dissolved out of the ore, with or without the aid of electricity, into an aqueous solution of ammonium chloride, and the metal is finally deposited by the electric current out of the solution. The extraction from the ore and the deposition may be carried out in the same cell, the pulverized ore being placed in bulk upon and around the anode. Mechanical circulation of the electrolyte is not recommended.

Diaphragm Cell.—A. E. Gibbs, 874,064, Dec. 17, 1907. Application filed June 2, 1906.

The construction of the cell is shown in Fig. 3. The outer vessel 2 of sheet steel is provided with an annular flange 3 around its top on which rests the projecting annular ring portion 4 of the cathode. A lower disc 5 is provided with an

upwardly projecting flange 6 of the same diameter as 7. Around the registering flanges 6 and 7 a barrel is formed consisting of the permeable diaphragm 8 jacketed by the cylindrical cathode 9. The diaphragm may be formed of asbestos. The metallic jacket which forms the cathode is made of sheet steel and is provided with a series of projections on one face and is perforated. The anode consists of a series of carbon rods 10. The feeding apparatus is as follows: 20 is the inlet pipe, feeding solution into the cup, while 21 is the flexible rubber tube connected to a pipe 22 within the cup, having a lateral inlet at one side. The flexible tube 21 leads through the bottom of the casing 2 and through the disc 6 being held

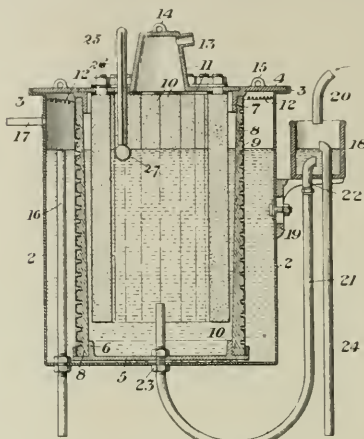


FIG. 3.—DIAPHRAGM CELL.

by the clamp connection 23. The cup is provided with an overflow pipe 24 which maintains a substantially constant level in the cup. A visible indicator of the height of the liquid in the cell is provided in form of the tube 25, which is closed at the top and open at the bottom and extends above the dome far enough to allow the stem 26 of the float 27 to be seen. The bulk of the cathodic electrolytic action takes place at the projections of the cathode; and as the caustic is formed there, the flow of electrolyte carries it outwardly through the holes of the cathode and out of the region of electrolytic action. The advantages of the invention are believed to result particularly from the cathode having points or projections entering the diaphragm.

Nickel from Nickel Sulphide.—J. N. Spring, 874,864, Dec. 24, 1907. Application filed Nov. 8, 1906.

By a chemical process of purification (see description under Recent Metallurgical Patents) nickel sulphide is obtained which is treated in a diaphragm cell as follows. Both compartments of the cell are filled with nickel chloride solution; the cathode consists of nickel, the anode of graphite. The nickel sulphide is fed into the anolyte and is held there more or less in a state of suspension or is fed in a thin layer down the flat faces of the anode. The "nascent" chlorine combines with the nickel from the sulphids, so that practically no chlorine gas is evolved at the anode. Sulphur gradually accumulates in the anode chamber, from where it is periodically removed and separated from the sulphides, for instance, by sublimation. Nickel is deposited on the cathode in a fine coherent form.

Manufacture of Nitro-Cellulose.—G. C. de Brialles, 874,564, Dec. 24, 1907. Application filed March 10, 1906.

This is an electrolytic process in which the losses and the dangers of manipulation in the manufacture of nitro-cellulose are avoided. It is carried out in a cell shown in Fig. 4. The

receptacle is formed of strengthened glass. The closure at the upper part is effected by a glass cover or stopper. This reservoir is furnished at its convex base with a branch 8 and a glass delivery valve 9. Towards the middle of the height of the reservoir on the interior of the wall a circular projection to is provided, strong enough to support a porcelain partition 11. Upon this partition, perforated with a number of holes, 12, is highly heaped the cellulose 13 to be nitrated. The reservoir is filled with a suitable mixture of concentrated sulphuric acid and ordinary nitric acid. A thermometer 14 is provided in the lower part of the cell; 16 and 17 are the positive and negative electrodes, respectively, being made of platinum or gilded platinum wire. They constitute a rheostat to moderately heat the liquid. "The active surface of the negative electrode must

be smaller than that of the positive electrode, so that the quantity of nitric acid involved will be the least possible. In order to obtain a good nitration of the cellulose it is necessary to have in solution a small quantity of nitrous acid, which is produced by the action of the hydrogen in contact with the negative electrode and the nitric acid." An excess of nitrous acid can be detected by the coloration of the liquid. In this case the surface of the negative electrode must be reduced, for instance, by enveloping part of it by asbestos cloth or spun glass. The cellulose immersed in the mixture of the two acids

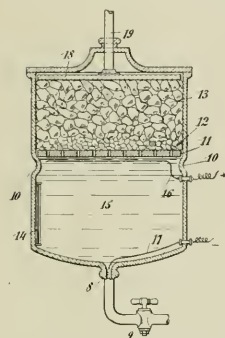


FIG. 4.—MANUFACTURE OF NITROCELLULOSE.

is nitrated in about 3 or 4 hours if the temperature does not fall below 30° C. In any case it ought not to exceed 40° C. After the completion of the process, the liquid is drawn off by a pump attached to a delivery tube, and "by the aid of porcelain disc 18, forming a piston mounted on a neck of the same material adapted to engage in a flexible stopper 19 of india rubber, a strong force can be exercised on the cellulose, in order to expel the absorbed acids." After all the liquid has been drawn off the cell is filled with water and the nitro-cellulose is washed until no longer any vapor is given off. The receptacle is then opened and the nitro-cellulose is submitted to further washings in the open air.

Electrodeposition.—W. Mueller and C. R. Murray, 874,374, Dec. 17, 1907. Application filed May 13, 1904.

Mechanical details of apparatus for electrodepositing metals for type matrices.

BATTERIES.

Primary Battery.—C. E. Hite, 857,880, June 25, 1907. Application filed Nov. 15, 1904. Assigned to Hite Electric Company.

To provide for proper circulation of the electrolyte through the different cells of a battery, the electrolyte in each of the cells communicates through the open bottom with a reservoir of electrolyte, common to all cells, and situated below the battery. By means of a pumping arrangement a flow of the electrolyte is caused from the reservoir upwardly through the cells, and then downwards upon the outside walls.

Primary Battery.—C. E. Hite, 858,391, July 2, 1907. Application filed Dec. 23, 1905. Assigned to Hite Electric Co.

This is a modification of the same general idea mentioned in the preceding patent. Claim 3 of patent 858,391 reads as follows: "In a primary cell, the combination of a receptacle having a plurality of compartments at its upper end and a reservoir beneath the compartments, the compartments open at the top and bottom, a pair of electrodes in each compart-

ment, an electrolyte common to reservoir and compartments, means for conducting the electrolyte from the compartments, as it becomes partially exhausted, to the bottom of the reservoir without mingling with the fresh electrolyte in the upper part of the reservoir, and means for conducting said fresh electrolyte from the upper part of the reservoir to the upper part of said compartments."

Primary Battery.—C. E. Hite, 858,392, July 2, 1907. Application filed Dec. 28, 1905. Assigned to Hite Electric Co.

The cell consists of three parts, vertically above each other. The middle part contains the set of electrodes inserted in porous mass of depolarizing material and incased in a coating of porous material, so as to form a solid porous block. The upper part of the cell is empty; the lower is filled with the electrolyte. When the cell is to be used, the whole cell is inverted and the electrolyte percolates gradually through the porous mass between the electrodes. When the whole electrolyte has percolated through and the cell is required to operate longer, it is again inverted.

Storage Battery.—C. Busch, 873,715, Dec. 17, 1907. Application filed June 25, 1907.

Claim 2 reads as follows: "In an electrical accumulator, an element consisting of a metallic envelope, formed of a sheet of substantially non-corrosive metal, folded so as to form a tube, active material contained within the said tube and the ends of the said envelope folded in so as to inclose the said active material, perforations in the walls of the envelope and a capillary lacing passing through the perforations and uniting the opposite walls in the manner of a sinuous winding."

Primary Battery.—H. C. Thomson, 866,748, Sept. 24, 1907. Application filed Dec. 21, 1903.

A circular battery zinc (a zinc cylinder with a slit) generally corrodes first at the water line. In order to prolong the life of the zinc the inventor provides the open edges of the slit with lips turned back toward and almost touching the zinc plate itself.

DISCHARGES THROUGH GASES.

Nitric Acid from Air.—H. Pauling, 873,891, Dec. 17, 1907. Application filed April 6, 1906. Assigned to Salpetersäure-Industrie-Ges.

When atmospheric nitrogen has been forced into combination with oxygen by heating air to a sufficiently high temperature (for instance, by means of electric discharges), it is important to cool the gas mixture quickly so as to prevent the dissociation of the nitrogen oxide formed. For this purpose it has been proposed to cool the gas mixture by blowing passive or indifferent gases into the gas mixture. Instead of any passive gas, the inventor employs part of the gas mixture produced before by the process. In this way the dilution of the gas mixture by inert gases is avoided.

RECENT METALLURGICAL PATENTS

IRON AND STEEL.

Chilled Castings.—C. J. Mesta (874,018, Dec. 17, 1907. Assigned to Mesta Machine Co.) has found that in the manufacture of articles of chilled cast iron the castings become more dense and tough and the depth of the chill is increased by the addition of a small percentage of vanadium to the chilling iron which is cast in the chill mold. For chilled rolls one-quarter of 1 per cent gives excellent results. The elastic limit and tensile strength is increased, the fatigue limit is increased, the wearing qualities are increased, and finally the roll will better resist expansion and contraction.

Treatment of Low Grade and Impure Ores.—Many non-Bessemer ores are highly silicious, and do not make good basic pig iron, and these ores are frequently high in sulphur, or, in some cases, the only fuels available for smelting them are

high in sulphur. With such ores and such fuels, in ordinary practice if the furnace is run hot, a silicious pig iron is produced which cannot be easily handled in a basic furnace. If the furnace is run cold, a sulphurous pig iron is produced which cannot be easily freed of impurities in the basic open hearth. This is especially true in the absence of manganese in the ores, a very frequent condition. H. O. Clute, of Cleveland, Ohio (874,391, Dec. 24, 1907), proposes to treat such ores by the following process: By using an excess of fuel, as compared with the ordinary smelting operation to produce basic pig iron in the blast furnace and thereby running such furnace very hot, the inventor states he can charge it with an ore mixture containing manganese and phosphorus, both preferably added as by-products resulting from a later operation, and with enough lime to make a basic slag, and thereby almost completely eliminate sulphur in the slag as manganese sulphide, producing a very hot and fluid pig iron, rich in silicon and phosphorus, all the phosphorus of the charge appearing in the iron. About half the manganese of the charge also appears in the iron, and such iron is practically saturated with carbon. The product of this operation is a highly silicious, very hot pig iron, which may be termed superheated, while the sulphur is mostly eliminated in the basic slag. This superheated iron can be readily desiliconized by dusting iron oxide on it. The silicon and manganese are removed, and the carbon begins to be attacked, while the phosphorus remains in the iron. The slag is skimmed off. The purified skimmed iron is still essentially pig iron, but is now largely freed from silicon, sulphur and manganese, but contains large amounts of carbon and phosphorus, rendering it an excellent material for treatment in a basic open-hearth furnace for removal of the carbon and phosphorus. The slag from the desiliconizing operation, which is silicate of iron and manganese, and the phosphoric slag from the open-hearth are returned to the blast furnace, as described above, so that the iron from the slag is recovered and the manganese and phosphorus are used over again. If manganese be absent in the ore, some must be procured. In running the furnace hot with sufficient fuel to produce the described pig iron, a rich gas is obtained, which may be advantageously employed in the auxiliary desiliconizing furnace and in the basic open-hearth furnace.

NICKEL.

Refining Nickel.—John N. Pring (874,864, Dec. 24, 1907) patents a process of refining crude nickel. As applied to the separation of nickel from copper refining waste in the form of crude sulphate, the process is as follows: The crude sulphate is dissolved in water to which is added a little sodium sulphide or nickel sulphide. The solution is agitated and filtered. Copper is thrown out as sulphide, together with As, Sb, Bi, Pb and Hg. The filtrate is then digested with an alkaline sulphide, black ash or calcium sulphide, and Ni, Co, Fe, Zn and Mn are precipitated as sulphides. Without separating these sulphides, the agitated liquor is digested with an acid to the point of neutralization. An excess of an acid, like hydrochloric acid, is then added, and after agitating for a short period it is found that nickel sulphide and cobalt sulphide alone remain undissolved. These are thus recovered: They may be further treated by electrolysis, as described in an abstract of the Analysis of Current Electrochemical Patents, in our present issue.

BLOWPIPE.

Oxy-Acetylene Blowpipe.—C. Delcampe, of Quincy, Mass. (874,492, Dec. 24, 1907) patents mechanical details of construction of a blowpipe comprising two separate pipes, one for acetylene, the other for oxygen. The exit end of the oxygen pipe is arranged within the exit end of the acetylene pipe which forms the mixing chamber of the blowpipe head. Both pipes are provided with detachable nozzles of capacities of a definite relation. When it is desired to change the size of the

flame, both detachable nozzles are removed and replaced by other nozzles of different capacity, but having the same definite relation, which yields the proper mixture of oxygen and acetylene.

SMELTING PROCESS.

Carbon Dioxide as Reducing Agent.—While in ordinary smelting operations carbon monoxide is the chief reducing agent, J. C. Hardie, of Helena, Mont. (874,336, Dec. 17), claims to be able to accelerate the smelting process materially by employing a blast of carbon dioxide gas with the addition of steam. The carbon dioxide gas is generated outside of the smelting furnace in a special gas generator, and, mixed with steam, it is supplied to the melting furnace in form of a blast through the tuyeres.

GOLD AND SILVER.

Cyanide Process.—Sulphides and pyritic and arsenical ores are treated according to the process of F. M. Johnson (873,943, Dec. 17, 1907) by putting the ore into a tank containing a solution of caustic soda and some stirring device. "While in this tank and being agitated it is subjected to the action of an electric current of high amperage and low voltage, derived from any suitable source of electrical energy. The result of the combined chemical and electrical actions on ores of this character is to remove sulphur and arsenic, to remove any iron present, to wholly or partially dissolve any silver and to effect a general decomposition of the mass which puts it in better condition for the cyaniding." The whole mass is then passed directly to the cyanide tank, wherein the gold is dissolved by the cyanide while the caustic soda continues its solvent action on the silver. When the gold and silver have been extracted from the ore, precipitation is carried out not with the customary zinc shavings but by means of simple plates of zinc and aluminium, which are bound together with copper strips. A flat plate of zinc is used between two flat plates of aluminium riveting copper strips around the ends, so as to bind all together into a single structure. With a plate of this character a perfect precipitation of both gold and silver is effected. If the ore requires no preliminary treatment, and is placed directly into the cyanide tank, caustic soda solution is added to the latter, so that the proportions of the caustic soda and the cyanide are about "equal in volume."

ALLOYS.

Chromium-Cobalt and Chromium-Nickel.—E. Haynes (873,745 Dec. 17, 1907) proposes the use of a chromium-cobalt alloy for articles requiring a high and durable lustre and possessing a high degree of hardness and resistivity to corrosion and oxidation, so as to be suitable for standards of weights and measures, etc., as a substitute for platinum, etc. It also possesses a high degree of hardness, so that it may be used as a substitute for mild tempered steel in the manufacture of edged tools such as table and pocket cutlery, physicians' and dentists' instruments, etc. The alloy is best worked into the desired form when heated to red heat. Alloys containing between 10 and 60 per cent of chromium may be employed. An alloy of 10 per cent of chromium with 90 per cent of cobalt has satisfactory hardness while not being brittle, but is not so resistive to corrosion as an alloy containing from 25 to 30 per cent of chromium. While an alloy containing 30 or more per cent of chromium is best suited to edged tools and like instruments. It is important that the metals are free from carbon, sulphur, etc. To produce the alloy a very high temperature is required; either the oxyhydrogen flame or the electric arc or the aluminothermic method may be employed. The same inventor (873,746, Dec. 17, 1907) has found that an alloy containing from 30 to 60 per cent of chromium and 70 to 40 per cent of nickel has similar properties. It may be best worked cold. The higher the proportion of chromium the harder is the alloy and the greater its resistance to tarnishability.

RARE METALS.

Purification of Tungsten, Etc.—Tungsten, molybdenum, tantalum, vanadium, chromium, etc., may be purified to such a degree of purity as to be suitable for incandescent lamp filaments, etc., by the following method of C. van Brunt (873,809, Dec. 17, 1907. Assigned to General Electric Company). For the purification of tungsten trioxide WO_3 , the inventor first prepares a solution in which this oxide becomes an alkaline tungstate. This may be done by fusing the oxide in alkali, such as Na_2CO_3 or by boiling it with an alkaline solution. The solution is then filtered and acidified with HCl to neutralize the alkali. This must be done with care, and the quantity of acid to be used should be such as to give approximately a molecular ratio of HCl to $WO_3 = 1.5$. If care is used the product is characterized by the ease with which it may be washed and filtered. The acidified solution is fractionally precipitated by a solution of benzidine-hydrochloride. The impurities present appear to be largely concentrated in the first fraction, the size of which is made dependent upon the amount of the impurities. In general it will not exceed a tenth part of all WO_3 present and may be much less. The second fraction is figured to contain the bulk of the WO_3 and is to be regarded as pure. It is necessary, however, that all of the WO_3 should not be precipitated, since otherwise impurities might be carried down. The tungsten precipitate is benzidine meta-tungstate. The hydration is small. The benzidine tungsten is then thoroughly washed with water and calcined at a low temperature in an unglazed porcelain crucible, whereby water and organic material are passed off, leaving only pure WO_3 . The latter is an impalpable powder, almost fluffy in lightness. Tungsten powder may be obtained from the WO_3 by reduction with hydrogen or otherwise and is exceedingly fine grained and uniform. By this method of purification the most minute traces of such elements as arsenic and iron are removed which would ruin the material for use in lamp filaments. In this way it is possible to purify a whole batch of oxide in a single day.

the records be perfectly clear, even though the loads are very light when the outfit is first installed.

The records are made on a novel semi-transparent smoked chart, which is periodically brought into momentary contact with the end of the recording arm by means of a special vibrating device. In this way a series of white dots are made

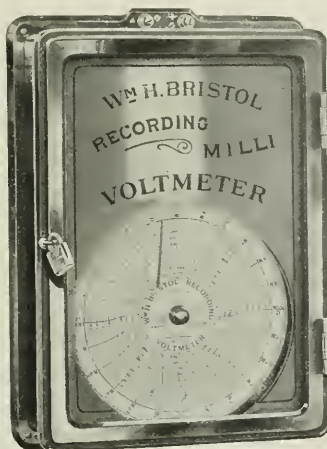


FIG. 1.—RECORDING MILLIVOLTMETER.

on the smoked surface, and these form a continuous line, and a record is thus made without causing any friction between the moving arm and the chart. The rate of vibration of the chart is timed to suit the frequency and range of the variation in the current to be recorded. The usual period of vibration of the chart is once in 10 seconds, but to obtain continuous lines where the fluctuations of the current are quite rapid, the vibrating attachment is made to operate twice every second.

The New Recording Millivoltmeter and Shunt Ammeter.

Electrical engineers have long felt the need for an accurate and sensitive recording millivoltmeter, which is adapted to practical everyday service as well as for laboratory tests. There has also been a demand for a recording ammeter of the shunt type, which can be connected by leads to the main bus-bar. The shunt system is especially economical where heavy currents are to be indicated or recorded, as the instruments may be located at a considerable distance from the main circuit, thus saving great expense in carrying the main conductors to the point where the instrument is located. The recorders illustrated herewith have been designed to meet these practical demands.

The two most important fundamental features of these recorders are a sensitive electrical movement of special design made by the Weston Electrical Instrument Co., and a new recording system using a patented smoked chart, so arranged that there is absolutely no friction between the recording arm and the chart.

These instruments are so sensitive that the recording arm will move over the whole scale for 5 millivolts or less, making it possible to accurately record one ten thousandth of 1 volt. The graduations on the chart are evenly proportioned over the entire range, the same as the Weston ammeter, so that even though there is only a small current flowing, the readings may be as readily taken as if the current was the maximum that the instrument would record. This feature will be greatly appreciated, as there are many places where it is important that

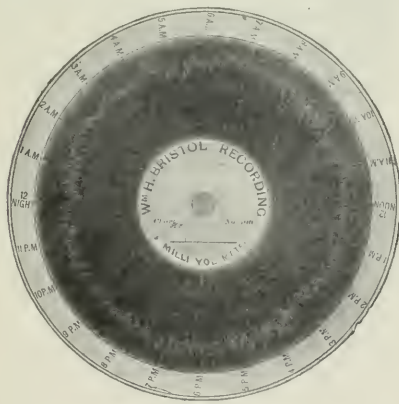


FIG. 2.—CHART TAKEN IN UNDERGROUND ELECTROLYSIS SURVEY.

When the record is completed the chart is dipped in a simple fixative solution which makes the record permanent for filing.

The recording millivoltmeter is shown in Fig. 1, and Fig. 2 is a reduced photographic facsimile of a chart taken from one of these instruments in connection with electrolysis surveys of underground structures which are being conducted by the Electrical Testing Laboratories of New York City. The graduations of this chart are arbitrary. It was revolved once in 24 hours and was vibrated once every 10 seconds. The

zero position of the recording arm was the middle of the scale, so that the record might be independent of the direction of the current, as in many cases the direction of the current changes from negative to positive during the day.

It is expected that by using a number of these instruments operating simultaneously at different points, stray currents in water and gas mains or in any underground structure may be recorded, making it possible to discover the causes of trouble and how they may be eliminated.

The recording ammeter is shown in Fig. 3 connected to a standard Weston 10,000-amp. shunt, to which is also connected a Weston indicating station ammeter. This illustration shows that the recorder may be readily applied to any standard shunt which is already in service, without disturbing the indicating instrument at the switchboard. As illustrated here, leads of almost any desired length may be used to connect the indicating and recording instruments to the shunt on the main bus-bar. It is even possible to have the recording ammeter located in the superintendent's office at a great distance from the shunt and the indicating instrument located on the switchboard convenient for the observation of the operator. Such

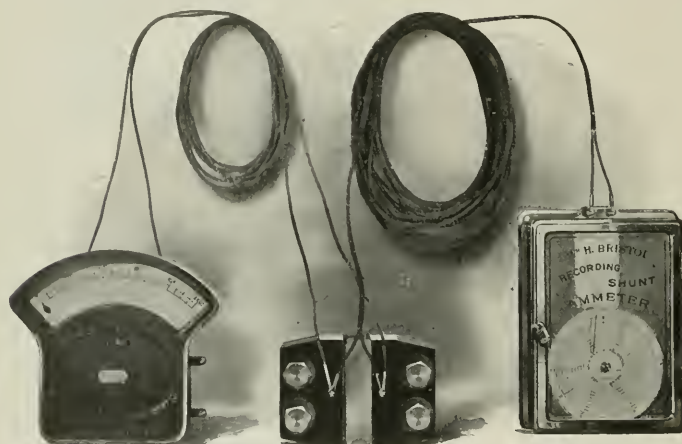


FIG. 3.—RECORDING AMMETER.

The recording shunt ammeter is connected to a 10,000-amp. Weston shunt, to which is also attached a Weston indicating station ammeter.

combination outfits could be furnished as units, with leads of the proper lengths to suit the individual cases.

The recording shunt ammeter has been successfully applied for taking continuous records of the current on a large trolley system, where the fluctuations are very rapid and varied as much as 4,000 amps. several times in a minute. The charts for such work as this are made to revolve once in 1 hour, and the vibrator operates twice in 1 second. For preliminary tests, the recorders are provided with special fast vibrators for the smoked chart and with a clock movement to revolve the chart once in 1 hour, but for continuous daily records the standard 24-hour charts are recommended.

These instruments are manufactured by William H. Bristol, 45 Vesey Street, New York City.

Color Photography.—At a meeting of the New York Section of the Society of Chemical Industry, held at the Chemists' Club on Dec. 20, Dr. Maximilian Toch presented a very interesting paper, illustrated by demonstrations and experiments on photography in the colors of nature. The subject was discussed by Dr. Toch along broad lines, but with special reference to the new Lumiere process.

Lead-Lined Iron Pipes.

The lead-lined and tin-lined iron-pipe industry was started in this country eighteen years ago by Mr. Thos. E. Dwyer, and has been carried on with steadily increasing success by the Lead Lined Iron Pipe Co., of Wakefield, Mass. This company furnishes at present over 100 water-works with pipe for all their services and thousands of feet of special pipe yearly for use on acids, etc.

The pipe is made as follows: A length of iron pipe is thoroughly pickled and

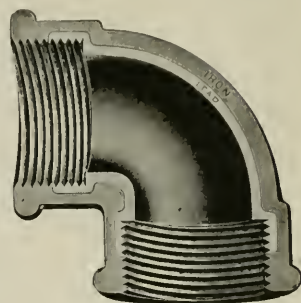


FIG. 1.—LEAD-IRON PIPE ELBOW.

given a bath of tin, which solders it inside and outside, making it, even before the introduction of the lining, a solid pipe which can have no pin holes in it. The lining of lead or tin is then introduced into the iron pipe by pouring molten lead or tin into it around a mandrel, and the lining is thoroughly fused onto the iron pipe, so that the whole pipe is one solitary unit. For this reason the pipe can be bent and cut and used roughly without any injury to the lining. The reasons why it has found so much favor with water-works are its cheapness, and the fact that the pipe may be put in a perfectly true line, or if desired may be just as easily bent to avoid rocks without injury to the lining. It may be cut and threaded as easily as any iron pipe. For water-works in whose districts there is danger of electrolytic action from the stray currents from tramway systems an extra heavy iron pipe is made,

which is, moreover, covered with a special coating. On account of the possibility of rough usage the tin-lined and lead-lined iron pipes are also largely used in buildings and houses.

In order to make the pipe applicable to all possible purposes, special fittings of all kinds are made such as lead-lined iron tees, tin-lined iron elbows, etc. Such an elbow is shown in Fig. 1. Lead-lined iron pipes are also very useful for boiler feed or hot water, as a pure lead lining does not corrode. It has also found wide application in pulp and paper mills, and the Lead Lined Iron Pipe Co. cut the pipe out to sketch of either wrought iron, cast iron or spiral riveted pipe with flanged or screwed joints.

For use with acids the joints on lead-lined iron pipes are flanged, thereby insuring a perfectly tight joint. Pure lead is

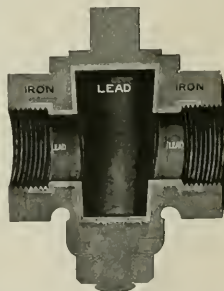


FIG. 2.—LEAD-IRON PIPE COCK.

used and the lead lining may be made of any thickness. Such pipes have been found very useful with all kinds of acids hot or cold. For use with hot acids hardened lead is employed. For pumping in mines and salt wells a special pump column pipe is made to stand any pressure specified. The joints are flanged together and the lead is recessed into the flanges to make the casket, making one continuous lead lining. These pump column pipes are in use in many of the largest copper and coal mines.

The same company makes lead-lined iron unions which need no washer, as the lead lining acts as that. The lining extends down into a portion of the threads, and there can be absolutely no corrosion. The lead is hardened and it can be used either with hot or cold liquids.

Fig. 2 shows a lead-lined iron stop cock. These cocks are either flanged or screwed, and they are lined with pure hard lead, which acids do not attack. The plug is made of an acid-resisting bronze, and the opening in the plug is thoroughly protected with lead. The plug part is made of bronze in order that it may work easier on the lead lining of the stop cock. It does not stick.

Lead-lined iron valves are made by the same company of the gate pattern; all interior parts being thoroughly protected with lead, so that corrosive acids or liquids have no chance to attack the iron. These valves have been subjected to the hardest kind of usage, both with salt water and acids, and have stood the test for the past eighteen years.

Besides lead-lined pipes the same company is now also making lead-covered coils, tubes and pipe, since there has been a constant growing demand for a pipe with a lead lining on the outside instead of the inside, the lining being fused to the outside in the same way as in the other type. Such pipes are, for instance, useful for passing steam through at a very high temperature while corrosive liquors are on the outside. These lead-covered coils are made of either brass, copper or iron.

Oxone and the Regeneration of Air.

As was already noticed in these columns, a gold medal has been awarded to the Roessler & Hasslacher Chemical Co. for their oxone exhibit at the Jamestown Exposition and a silver medal to Dr. Richard von Foregger of the same company for the exhibit of the process of regeneration of air by means of oxone.

The latter process, which was exhibited in practical use in the Radium Booth of the Government, is the same as was demonstrated by Dr. von Foregger at a local meeting of the American Electrochemical Society in New York, 1906, and at the general meeting of this Society in Ithaca, N. Y., reports on which were given space in this journal. Those experiments were made mainly for the purpose to supply an efficient and absolutely reliable means for the regeneration of air in submarine boats. The apparatus necessary for the working of this process was in the meantime worked out for other practical uses. The illustrations show the steps made from the first experimental apparatus to the present state.

The apparatus consists of two parts, a blower and a wire cage revolving in a cylinder. The wire cage contains the oxone, which, when the air is blown over same, undergoes that decomposition which produces the generation of oxygen and the absorption of carbon dioxide as well as toxic parts of exhalation, ordinarily termed "foulness of the air."

A short description which is found at the exhibit may illustrate the process:

"This apparatus is capable of regenerating the air in closed spaces. It automatically maintains the constitutional proportion of oxygen in air (in its normal percentage 20-21 per cent.), absorbs all carbon dioxide and purifies. Under given conditions it thus preserves a healthy composition of the atmosphere.

It will not decrease the prevailing temperature, but will decrease the humidity, which renders the stay in higher temperature so unpleasant. This apparatus works at its highest efficiency when the conditions are most severe, *e. g.*, when the atmosphere, vitiated by animal breath, is entirely shut off from



FIG. 1.—OXONE APPARATUS.

the outside air, and also when the same is uninfluenced by any artificial change."

The last sentence in this description is comprehensible, when we consider that the grade of the decomposition of oxone depends on the amount of humidity furnished exclusively by the exhalations of those in the closed space. If this humidity has no other way out it is all bound to react upon oxone, which accounts for the automatic working of the process, *i. e.*, the more men contained in the room the greater the decomposition of oxone; there is a strict proportionality between the two factors.

Oxone, as everybody may know by this time, is electrically fused sodium peroxide containing a catalytic substance. The absorptive power of the caustic soda paste formed by the decomposition of oxone is not confined to the CO₂. Although not much is known about the great variety of toxic products of exhalation, experiments have shown that these organic

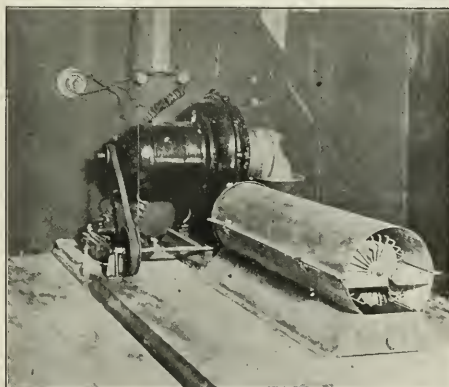


FIG. 2.—OXONE APPARATUS.

substances are either directly absorbed by the caustic soda or they are oxidized when coming in contact with the nascent oxygen on the surface of oxone; thus, bacteria is destroyed and odors are positively eliminated.

The latter property, the only superficial test by which the strange observer can go, was particularly remarkable in the dark room in Jamestown. Visitors of former years of the Government Radium Booth in the various expositions, according to many reports which were heard and read, were agreeably pleased by the much improved conditions in this year's Radium Booth.

There was another little apparatus on exhibit, consisting of a 1/16-hp. electric fan motor, the fan only being 4 inches in diameter, and a device in front to hold a cylindrical cake of about 7 ounces of oxone. This apparatus, called "oxygator," is meant for office work, and should take the place of the regular fan motor during the winter months.

This process of regeneration of air, which we might term "internal ventilation," is, apart from its usefulness for hospitals, public rooms, work in mines, etc., very adapt for application in cold storage rooms. There the two propositions, to reduce humidity of the air to the utmost and to destroy or prevent germination, would be met with one function. Oxone has been and is being very successfully used in cold storage rooms for deodorization. This is done in a rather crude

Mr. Henry S. Blackmore, Judge Hough, sitting in the Circuit Court of the United States, Southern District of New York, has decided that Mr. Blackmore's reissued patents 11,995, of May 29, 1902, be revoked and declared null and void, because the reissue not only enlarged the claims of the original patent, but sought to cover an entirely different alleged invention. The Blackmore patent refers to the manufacture of sulphuric acid, and some of its claims are found to interfere with the contact-process patent of Knietseh, who is found to be the prior inventor. The Knietseh patent is owned by the General Chemical Co.

Dry Cells for Gas and Gasoline Engine Ignition.—The National Carbon Co., of Cleveland, Ohio, have just brought out a new dry cell, called the "red top" Columbia Ignitor. It is intended for gas and gasoline engine ignition on automobiles, motor boats, stationary engines, etc. On account of the special design for this purpose these cells are claimed to perform longer service than any other battery of corresponding size.

Combine of American and German Optical Works.—A great combine of three very important American and German

optical manufacturing companies has just been effected. The Bausch & Lomb Optical Co. and the Bausch, Lomb, Saegmuller Co., both of Rochester N. Y., and the Carl Zeiss Optical Works, of Jena, Germany, have joined interests for the purpose of carrying to the highest possible development the production of optical, physical and engineering instruments. As a result of this association the Bausch, Lomb, Siegmuller Co. joins the Bausch & Lomb Optical Co., and becomes an integral part of its organization, while the Carl Zeiss works maintain their entity at Jena, inasmuch as by their own articles of incorporation they are bound to exist in perpetuity, and at the same time they become members of the corpor-

ate organization, Bausch & Lomb Optical Co. of Rochester, N. Y. The scientific staff, data, formulæ and magnificent inventions of Carl Zeiss, the excellent and enlightened business organization, scientific staff, experience and skill of the Bausch & Lomb Optical Co. and the inventions, experience and skill of the Geo. M. Saegmuller Co. have thus been united to give the scientific and engineering world optical, physical and engineering instruments and apparatus of the highest possible perfection.

A Limited Company for Electric Steel Plants.—The "Gesellschaft für Elektrostahlanlagen mit beschränkter Haftung, Berlin-Nonnendamm," is a union of the Eicher Hütten Verein, Le Gallais-Metz et Cie. in Dommeldingen, Engineer Paul Gredt, in Luxemburg, the Röchling Eisen und Stahlwerke, of Volklingen, the Metallurgiska Aktiebolaget in Stockholm and the Siemens-Halske A. G., in Berlin. This combination is to exploit the patents and patent applications owned by these companies, for the production of iron, steel and ferro-alloys, to exchange experience and grant licenses in all countries except Great Britain and its colonies, the United States, Sweden and Norway. The Swedish company named above remains the sole licensee in Sweden and Norway; the Gröndal-Kjellin Co. in London is sole licensee for Great Britain and its colonies and the United States. The manager of the new combination, Chief Engineer Victor Engelhardt, of the Siemens-Halske A. G.



EXHIBIT OF ROESSLER & HASSLACHER CHEMICAL CO. AT THE JAMESTOWN EXPOSITION.

manner by placing, according to the size of the room, a certain number of half-filled water buckets in the same, throwing into each a few pounds of oxone and closing the doors. After 24 hours bad odors coming from a half-year or a year's storage without ventilation have entirely vanished.

The exhibit shows the various cast shapes of oxone. It shows hydronc, the material which in a similar manner produces pure hydrogen gas upon contact with water. This is a lead sodium alloy. Other exhibits were the various peroxides and perborates, manufacture of which is partly done by the Niagara Electrochemical Works, of Niagara Falls, and partly by the Roessler & Hasslacher Chemical Co., of Perth Amboy, N. J.

Notes.

Erratum.—In the letter of Mr. Robert Sticht, published on page 302 of our last volume, the word "silica" should be substituted for silicon in the third line from the bottom.

The Crocker-Wheeler Co., of Ampere, N. J., have sent us a bound complete set of their bulletins. Among those of special interest to our readers are bulletins No. 83 (generators for electrolytic refineries), 84 (gas-engine driven alternating-current generators) and 85 (motors for rolling mills).

Patent Suit.—In the suit of the General Chemical Co. vs.

The Brass Foundry.—A very interesting and suggestive paper was recently presented by Mr. W. S. Quigley before the New York Railway Club on "the brass foundry." The author pointed out how much the brass foundry has been neglected in the past and how much more efficient its operation can be made by modern methods of melting and handling metal. He referred to the radical change brought about by the introduction of the oil furnace. "It is an indisputable fact that the oil furnace is here to stay, is recognized as standard brass foundry equipment and as an economical and efficient melting machine. During the last four months the Rockwell Engineering Co. alone have sold seventeen double-chamber melting furnaces, with a nominal melting capacity of over 40 tons per day, and I have no doubt that the Hawley Down Draft Furnace Co. have sold furnaces comparing favorably with the above output." The author then gave a great many examples from actual practice, showing the good that can be done by modern methods, and especially the economy that can be obtained with the Rockwell double-chamber melting furnace.

Pennsylvania State College.—Mr. J. P. Jackson, professor of electrical engineering at the Pennsylvania State College, has been appointed by the board of trustees to the position of Dean of the School of Engineering.

American Peat Society.—The American Peat Society, to the formation of which we referred in our October issue, has the following officers for the first year: President, Dr. Joseph Hyde Pratt, State geologist of North Carolina; secretary, Julius Bordollos, Kingsbridge, New York City; treasurer, Henry G. Halloran, Postoffice box 1816, Boston, Mass.; vice-presidents, M. R. Campbell, R. Ransome, C. G. Kleinstuck and Dr. J. McWilliams. The yearly membership fees are \$5 for active members and \$2 for associates.

American Electrochemical Society.—At the meeting of the board of directors, held in Philadelphia on Nov. 6, the following gentlemen were elected members: Dr. Howard D. Smith, Beloit College, Beloit, Wis.; William H. Bassett, the American Brass Co., Waterbury, Conn.; H. Clyde Snook, president, Roentgen Manufacturing Co., Philadelphia, Pa.; John Clement Bradley, American Brass Co., Waterbury, Conn.; Prof. Dr. F. Fichter, University of Basel, Switzerland; Wm. C. Geer, chief chemist, the B. F. Goodrich Co., Akron, Ohio; Dr. Georg Langbein, Koeniglich Saechsische & Hofrath, Leipzig, Germany; Dr. Axel O. Appelberg, General Electric Co., Schenectady, N. Y.; Dr. Colin G. Fink, General Electric Co., Schenectady, N. Y.; Dr. Charles F. McKenna, chemical engineer, 155 West 91st Street, New York City; Amos G. Reeve, Oneida Community, Niagara Falls, N. Y.; Jasper Whiting, Rumford Falls, Me.; William D. Crumie, United States Appraiser's Department, New York City; Edward J. Lavino, E. J. Lavino & Co., Philadelphia, Pa.; A. M. Williamson, International Acheson Graphite Co., Niagara Falls, N. Y.; A. Bernard Draeger, proprietor of the Draeger Works, Luebeck, Germany; Dr. C. H. Sharp, Electrical Testing Laboratories, New York City; Jacob Hasslacher, president the Roessler & Hasslacher Chemical Co., New York City; Count A. de Riva-Berni, general manager, Comptoir International de Vente du Ferro-Silicium, Paris, France; Robert Deissler, civil engineer and patent attorney, Berlin, Germany; Frank Hemingway, manufacturing chemist, New York City; W. Ferris Hendry, Western Electric Co., New York City; Arthur J. Hudson, patent attorney, Cleveland, Ohio; George Morey, Jr., University of Minnesota, Minneapolis, Minn.; Judson G. Snull, New Jersey Zinc Co., Franklin Furnace, N. J.; Roland Calberla, electrochemical engineer, New York City; Prof. Alexander Krakau, Electrotechnical Institute, St. Petersburg, Russia. At the meeting of the board of directors, held in New York on Dec. 27, the following gentlemen were elected members: Dr. Lars William Oholm, University of Finland, Helsingfors, Finland; John L. Polk, Rensselaer Polytechnic Institute, Troy, N. Y.; Prof. Dr. Kamejiro, Yoshikawa, Im-

perial University, Kyoto, Japan; Walter C. Smith, A. C., United States Metals Refining Co., Chrome, N. J.; John B. Lewis, University of Texas, Austin, Tex.; W. H. Erhart, vice-president, Charles Pfizer & Co., New York City; Robert H. Hartley, Hartley Building, Pittsburg, Pa.; Hugo J. Wichmann, United States Food and Drug Inspection Laboratory, St. Paul, Minn.; Herbert A. Baker, American Can Co., Paulsboro, N. J.; Meyer Schlamberg, chemist and mining engineer, Philadelphia, Pa.; Wilbur F. Hurlburt, American Electric Furnace Co., New York City; Johan Winsnes, Vadheim Elektrochem. Fabrik, Vadheim, Sogne, Norway; Frederick V. L. Hiorth, electrochemical engineer, Christiania, Norway; Lewis E. Saunders, Norton Emery Co., Niagara Falls, N. Y.; James M. Neil, technical chemist, Toronto, Can.; Dr. Franz H. Hirschland, manager, Goldschmidt Chemical Co., New York City; Prof. Arthur B. Lamb, New York University, New York City.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

CALCIUM CARBIDE (Continued.)

No. 612,694, Oct. 18, 1898, Heinrich Aschermann, Cassell, Germany.

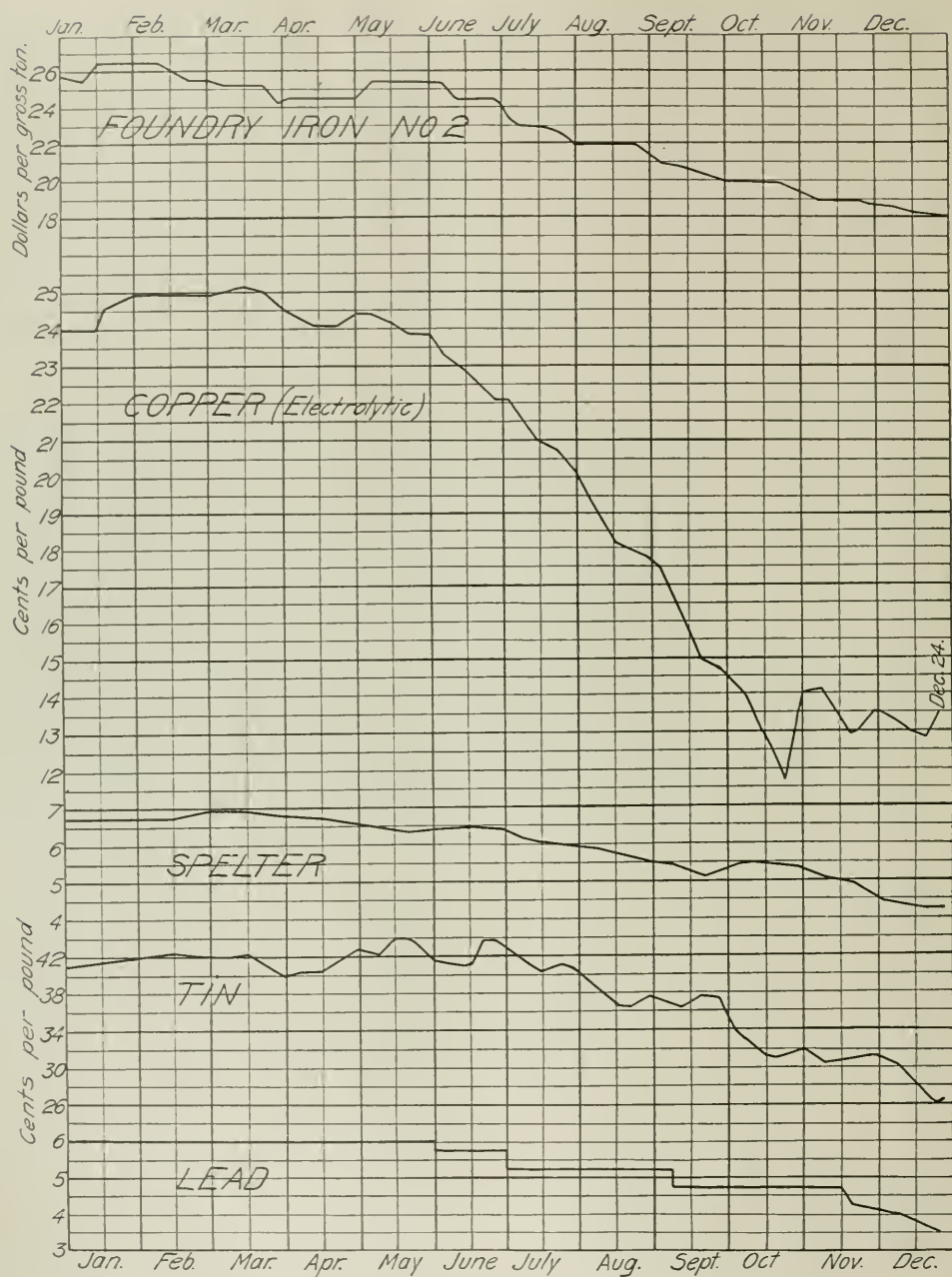
Simultaneously produces carbid and metals by electrolytically smelting a mixture of an oxid of one metal, a sulfid of a different metal and carbon. The carbon reduces both metals and combines with the one for which it has the greater affinity. The other reduced metal, if non-volatile, sinks to the bottom of the molten mass; if volatile, it is vaporized and condensed. For example: Smelts a mixture of iron pyrites, lime or limestone and carbon, producing calcium carbid, iron and sulfur dioxid. Alloys may be made by simultaneously reducing several metallic oxids or sulfids. Specifies a saving in electric current of 40 per cent.

No. 628,806, July 11, 1899, William Smith Horry, Sault Ste. Marie, Mich.

Smelts the charge by passing an electric current between the lower ends of depending parallel electrodes and through a pool of carbid beneath them and extending laterally beyond the field of reduction. The charge-mixture surrounds the electrodes and protects them from the air, being preheated by the escaping gases and retaining the heat. The carbid and charge-mixture and the electrodes are shifted vertically with respect to each other, to bring successive portions of the charge into the field of reduction. Three types of furnaces are shown. The first is an annular trough or wheel having removable casing-plates. The electrodes depend into one portion of the trough, which is gradually rotated to remove the pig of carbid from the zone of reduction. The second furnace has vertical metal walls and a bottom which is gradually moved downward as reduction proceeds, to carry the pig of carbid away from the zone of reduction. The third furnace consists of vertical, tubular superposed sections which are gradually moved downward, a section being added at the top as required.

No. 630,966, Aug. 15, 1899, Ludwig K. Böhm, N. Y. City.

Feeds charge downward through a tubular upper electrode consisting of a series of vertical carbon bars from 2 to 4 inches in diameter and 24 inches long, hold at the top in a copper ring casing. The lower electrode is a horizontal iron vessel, sliding on one iron plate. As this vessel fills with carbid, it is slid out and replaced by another. The bottom of the vessel is initially covered with a layer of carbid. The charge-feed is regulated by a rotating wheel. A central carbon bar may be placed in the upper electrode.



FLUCTUATIONS OF METAL PRICES DURING 1907.

(For explanation see page 4.)

NEW BOOKS.

STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS.—By R. C. Beardsley, Louis Bell, H. M. Hobart, Otis Allen Kenyon, Edward Lyndon, A. S. McAllister, Kempster B. Miller, William H. Onken, E. F. Roerber, George Shaad. Twenty sections: units, circuits, instruments and measurements, central stations, transmission and distribution, illumination, electric traction, electrochemistry, telephony, telegraphy, miscellaneous applications of electricity, wiring standardization rules, tables and statistics. Bound in flexible morocco; over 1,300 pages, and 1,260 illustrations. Price, \$4.00 net, postpaid: New York: McGraw Publishing Co.

STEEL WORKS ANALYSIS.—By John Oliver Arnold and F. Ibbotson. Third edition, thoroughly revised and enlarged. 468 pages, 24 illustrations. Bound in cloth. Price, 10s. 6d. net. London: Whittaker & Co., and New York: Macmillan Co.

THE METALLURGY OF IRON AND STEEL.—By Bradley Stoughton. Illustrated. Bound in cloth. Price, \$3.000. New York: Hill Publishing Co.

SALDATURE AUTOGENE DEI METALLI.—By Prof. Ing. S. Ragno. 193 pages, 18 illustrations. Bound in cloth. Price, 2 lire (retail price in New York 50 cents). Milan, Italy: Ulrico Hoepli.

WESTERN BLUE BOOK AND BUYERS' REFERENCE.—Containing a complete classified list of all the constructional engineering, electrical, mechanical, mill, mining, foundry, iron, steel, quarry, machinery, railroad and kindred industries. Bound in cloth. Price, \$5.00. Chicago, Ill.: Milton E. Lowitz Publishing Co.

MINING, MINERAL AND GEOLOGICAL LAW.—By Charles H. Shamel. Over 600 pages, 100 illustrations. Bound in cloth. Price, \$5.00 postpaid. New York: Hill Publishing Co.

MATHEMATICAL HANDBOOK.—Containing the chief formulas of algebra, trigonometry, circular and hyperbolic functions, differential and integral calculus, and analytical geometry; together with mathematical tables. By Edwin Pliny Seaver. 288 pages. Bound in cloth. Price, \$2.50. New York: McGraw Publishing Co.

THE METRIC AND BRITISH SYSTEMS OF WEIGHTS, MEASURES AND COINAGE.—By F. Mollwo Perkin, Ph. D. 84 pages, 17 diagrams. Bound in cloth. Price, 1s. 6d. net. London: Whittaker & Co., and New York: Macmillan Co.

TURBINES, WATER AND STEAM.—By A. E. Tompkins. Illustrated. Bound in cloth. Price, \$1.50 net. New York: Edwin S. Gorham.

CARBURETING AND COMBUSTION IN ALCOHOL ENGINES.—By Ernest Sorel. Translated from the French by Sherman M. Woodward and J. Preston. 275 pages; illustrated. Bound in cloth. Price, \$3.00. New York: John Wiley & Sons.

THE BLACKSMITH'S GUIDE. Instructions on forging, welding, hardening, tempering, casehardening, annealing, coloring, brazing and general blacksmithing.—By Francis J. Sallows. 163 pages; illustrated by colored plates and diagrams. Bound in cloth. Price, \$1.50; leather binding, \$2.00. Brattleboro, Vt.: Technical Press.

GRAPHITE, ITS PROPERTIES, OCCURRENCE, REFINING AND USES.—By Fritz Cirkel. 307 pages, profusely illustrated. Bound in paper. Ottawa, Canada: Department of Mines, Mines Branch.

UNITED STATES GEOLOGICAL SURVEY:

Experimental work conducted by the chemical laboratory of the United States fuel-testing plant, St. Louis, January 1, 1905, to July 31, 1906. By N. W. Lord. 49 pages. A study of four hundred steaming tests made at the fuel-testing plant, St. Louis, Mo., 1904, 1905 and 1906. By L. P. Breckenridge. 106 pages.

The San Francisco earthquake and fire of April 18, 1906, and their effects on structures and structural materials.

By G. K. Gilbert, R. L. Humphrey, J. S. Sewell and Frank Soule. 170 pages, 57 plates.

Twenty-eighth annual report of the Director of the United States Geological Survey, George Otis Smith, director. 80 pages, 1 illustration.

Advance chapters from Mineral Resources of the United States for 1906, Washington, D. C.:

Summary of the Mineral Production of the United States in 1906. By William Taylor Thom. 57 pages.

The Production of Platinum in 1906. By David T. Day. 16 pages.

The Production of Mineral Paints in 1906. By Edwin C. Eckel. 12 pages.

The Production of Lime and Sand-Lime Brick in 1906. By Edwin C. Eckel. 11 pages.

The Production of Gold and Silver in 1906. By Waldemar Lindgren and others. 265 pages.

The Production of Copper in 1906. By L. C. Graton. 70 pages.

The Production of Zinc in 1906. By J. M. Boutwell. 35 pages.

BOOK REVIEWS.

THE CHEMISTRY OF COMMERCE. A simple interpretation of some new chemistry in its relation to modern industry. Robert Kennedy Duncan, Professor of Industrial Chemistry at the University of Kansas. Small 8vo.; 263 pages; 23 illustrations. Price, \$2.00. Harper & Bros., New York and London, 1907.

There is a breeziness about this book which suggests the wind-swept plains of Kansas; it abounds in puns, humorous touches, unexpected homely illustrations; it is as readable as Jules Verne and, moreover, is *not* fiction.

The twelve chapters are on Catalysis, Fixation of Nitrogen, the Rare Earths, High Temperatures, Glass Making, Industrial Alcohol, Floral Perfumes, Medicines, Microbe Inoculation, Cellulose and Industrial Fellowship. Taking the most electrochemical chapter, the fixation of nitrogen, it is handled as by a chemical and electrical expert; the latest discovery is there, explained in simple and yet accurate language. The same masterly grasp is apparent in all the chapters, combined with a most unusual ability to make clear to the non-technical reader. The technical reader, however, no matter how much he knows about the subject handled, will find the treatment interesting and very probably get new information or new ideas from it.

The final chapter deserves more than passing notice. The professor states what is undoubtedly true: "American manufacture is a chaos of confusion and waste. The confusion and waste, it should be said, are chemical, not mechanical. Along the lines of mechanical contrivances America need acknowledge no peer." The plea for the greater use of industrial chemistry is then pressed home with fervor. The point is made that chemists in the works, even when they are employed, are usually incapable of making all the progress which is possible, that they are often "killed by their own routine." A chemist may analyze, sensibly and accurately, the soda and lime and sand used in making glass, but he could not thereby determine the science of glass making; that kind of service was rendered by the professors from the University of Jena.

The manufacturer, the industrial chemist, the investigating chemist and the university professor must constitute the fellowship of interest and action necessary for the highest results. Such is the plan which has made Germany the scientific workshop of the world, the pattern for us as for all crude and wasteful butchers of Nature's prodigality. The manufacturers tried too long to get on without the chemist in their works, they have gone too long now without the co-operation of the

university. It is riddled with a particular difficulty to solve may, by combining, enable at very small expense a University Fellowship for original scientific work on their problem, and all the contributors share equally in the benefits attained. The young men holding such fellowships would become invaluable to the industry. In fact, should become its scientific leaders.

We heartily commend Prof. Duncan's book to all our readers. Its reading will be relaxation and improvement combined, pleasure and business, instruction and inspiration.

* * * * *

STEEL WORKS ANALYSIS. By Arnold and Ibbotson. Third edition; thoroughly revised and enlarged. 468 pages; 24 illustrations. Bound in cloth. Price, 10s. 6d. net. London: Whittaker & Co. New York: Macmillan Co.

The present edition of this standard British work on steel works analysis has 118 pages more than the edition of 1900. This increase has been made necessary by the growing complexity of the analytical problems presented to the analyst by the use, in special steels, of the elements vanadium, molybdenum, titanium, etc. New and more rapid methods are also given, and the section on gas analysis has been revised. The latest method for the calorimetry of fuels is fully described. A new feature of the book is the inclusion of methods for the analysis of bearing metals, brasses, bronzes and white metals. A brief chapter has been added on the analysis of high-speed steels.

The descriptions of methods are given with sufficient minuteness, and in nearly every case the reasons, theoretical and practical, underlying the methods, are given clearly enough to enlighten those whose training has not been of the broadest.

In a work in many respects so admirable and reliable it is surprising to find, under direct combustion of steel for carbon determination, the following recommendation to secure a sample sufficiently fine for successful combustion by the method given: "The drillings should, obviously, be as thin as possible. It is often possible from a packet of drillings submitted for analysis, to pass several grains through a sieve of 30 meshes to the linear inch, and this provides a most admirable sample."

It is well known to many that this is a most risky proceeding, for in many instances the finer portions of a sample of drillings are very materially higher in carbon, phosphorus, etc., than the coarser portions.

* * * * *

A MANUAL OF FIRE ASSAYING. Chas. H. Fulton, President of the South Dakota School of Mines. 8vo.; 178 pages; 44 illustrations. Price, \$2.00. New York: Hill Publishing Co.

Professor Fulton has been an assayer, superintendent of works, and is now professor of metallurgy; he, therefore, possesses the qualifications to write and speak with authority. He has put his experience, his learning and his personality into this book and made it one of the best guides to fire assaying yet produced. In the first chapter, on furnace and tools, we find at once the concise description, just criticism and valuable practical touches which are characteristic of the whole work.

One very important item, usually entirely ignored, is the continual reference to the reliability of apparatus and costs of operation, the latter reckoned out as so many cents per assay. Under the descriptions of fluxes, slags, reducing agents and operations, we find the chemistry of the assaying lucidly and accurately explained, so that the assayer may know exactly what he is doing instead of merely follow a set of rules. The discussion of slags is particularly modern. We commend the author for avoiding the awkward designations of ortho and meta-silicate, but cannot agree with him that $4RO \cdot SiO_2$ is the only sub-silicate. Surely, the professor knows that it is not, but his readers would think that it was. A little more explanation of the "silica" or "quantivalent" ratio would have made matters clearer.

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The chapter on cupellation is probably the most illuminating treatment of this subject to be found in any work on assaying; there is no practical assayer but can learn considerable from it. Under the heading *Tellurium* the reason for the splitting up of the beads during cupellation—the lowering of the surface tension of the lead—escaped the author; the consideration of this fact (pointed out first by Dr. J. W. Richards) gives a very satisfactory explanation of the phenomenon and suggests methods of correction, such as the addition of antimony to such alloys to increase their surface tension during cupellation. The rest of the work, on parting, crucible assays, etc., is complete and full of originality. Altogether, the work is a breath of fresh air in a rather musty corner of the chemical laboratory, and is heartily recommended to all who wish to progress in assaying.

* * * *

ANNUAIRE POUR L'AN, 1908. Published by the Bureau des Longitudes (Paris). 760 pages, with six appendices. Price, francs 1.50 (retail price in New York, 50 cents). Paris: Gauthier-Villars.

The present volume of this well-known excellent little French yearbook contains, besides astronomical tables (401 pages), compact tables relating to physics and chemistry, such as tables of densities, vapor tensions, specific heats, solubilities, electric units, etc. A chapter of 47 pages, prepared by Berthelot, and giving the most important thermochemical data in a very handy form, should prove specially attractive and useful.

* * * *

THE METALLURGY OF THE COMMON METALS. Leonard S. Austin, Professor of Metallurgy and Ore-dressing, Michigan College of Mines. 8vo.; 407 pages (no index); 171 illustrations. Price, \$4.00. San Francisco: Mining and Scientific Press.

The title is misleading, in that only gold, silver, iron, copper, lead and zinc are considered; surely antimony, aluminium, nickel, mercury, platinum and tin are also common metals. But, as it is, the author has tried to cover too much ground in the space. All that is said is well said, but so much that is necessary to understanding it is left out, that the book can be of little use to a student who knows nothing of the subject, and is of less use to the practiced metallurgist who is tolerably familiar with his art.

In the seventy pages given to *Gold*, no description is given of hydraulic or dredging, and we cannot agree with the author that these processes "belong rather to mining engineering than to metallurgy." Surely, any method by which a metal is extracted from an ore is a metallurgical process. The well-written forty-five pages on the cyanide process makes some amends. The short chapter on silver is similarly incomplete, because of the total omission of (even the name of) the Patio process; the rapidly increasing importance of cyaniding silver ores is not suitably recognized in the one short page given to it.

In the twenty-four pages given to the metallurgy of iron, there is no attempt made to describe anything but the manufacture of pig iron. Since this is farther from being iron *per se* than either steel or wrought iron, it is hard to see why one should have been described and the other two left unmentioned. The incompleteness of the book reaches its maximum at "Iron." Under *Zinc* no reason is given why the process has to be one of distillation, the boiling point of zinc not being even mentioned.

A final chapter of thirty pages, on commercial considerations, is fairly satisfactory. Throughout the work a commendable effort is made to introduce thermochemical data, and thus give some idea of the why and wherefore; it should have been modified, however, by the conditions under which the reactions take place, *c. g.*, at $t.050^{\circ}$ in the metallurgy of zinc.

The reviewer's opinion is that the work is not an abridged

treatise on the common metals, such as its title would lead one to suppose, because it omits half of them; it is not even a complete review of the metallurgy of those metals which it takes up, for it omits altogether important processes, and in the case of iron, the larger part of its metallurgy. But what is written averages "good."

* * *

THE ELECTRIC FURNACE IN IRON AND STEEL PRODUCTION.
John B. C. Kershaw, F. I. C. 12mo., 68 pages, 24 illustrations. Price, 5 shillings. London: The Electrician Printing & Publishing Co., Ltd.

This is a reprint of a series of articles published in the *Iron Trade Review*, in 1906; also in *The Electrician* (London) at a later date. These articles have already been reviewed and criticised in our columns. Placing the whole together, in one volume, however, has certainly enhanced their value, and while the criticisms as to their sketchy nature and incompleteness are still true, yet, as a volume, they may be recommended as a welcome addition to the rather scanty literature yet extant on this subject in the English language.

* * *

MATHEMATICAL HANDBOOK. Containing the brief formulas of algebra, trigonometry, circular and hyperbolic functions, differential and integral calculus and analytic geometry, together with mathematical tables. Selected and arranged by Edwin P. Scaver, A. M., LL.B., formerly Assistant Professor of Mathematics in Harvard University. 279 pages. Price, \$2.50 net. New York: McGraw Publishing Co.

"The uses which this book may serve hardly need to be pointed out. Some years ago the author composed the part relating to trigonometry and used it as a syllabus for instruction in his college classes. It served its purpose and soon went out of print. But a stray copy of it found its way to the table of a well-known civil engineer, to whom it proved constantly useful, and by whom it was often referred to as 'his memory.' This engineer has suggested a revision and republication of the original book with important enlargements. Accordingly there have been added sections on algebra, the differential and integral calculus and analytic geometry. The subject of hyperbolic functions, which now receives much more attention than formerly, has been more fully treated. Tables have been added, which include not only those universally used, but also some—like those of the hyperbolic functions, of the natural logarithms of numbers, and that of the velocity of falling bodies ($v = \sqrt{gh}$)—that has been hitherto not readily accessible."

It seems to the reviewer that a book of this kind cannot do any harm, but can do very much good. Though nothing is more dangerous than the injudicious use of formulas, yet this book can hardly produce such an effect, since the explanations are so short that the formulas can hardly be applied by anybody who does not master the underlying principles and methods of calculation.

On the other hand, there is no necessity for anybody to know formulas by heart, if it is possible to look them up quickly; and the unnecessary loading up of the memory with a mass of formulas has contributed more than anything else to the regrettable fact that mathematics is simply distasteful to a great many logically thinking men. If this book will serve as the "mathematical memory" of its users, it will be useful.

The chapter on differential and integral calculus (44 pages) will be particularly useful to many. The integration of linear differential equations, differential equations of the second order and of differential equations of the n th order, with constant coefficients is given. If the author adds in a future edition those *partial* differential equations which are of fundamental importance in the potential theory, in the theory of heat and in mathematical physics in general, the value of this chapter to engineers would be considerably enhanced.

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VOL. VI.

NEW YORK, FEBRUARY, 1908.

No. 2.

Electrochemical and Metallurgical Industry

With which is Incorporated Iron and Steel Magazine

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[Incorporated.]

239 WEST 39TH STREET, NEW YORK.

J. W. RICHARDS, PH. D. President
E. F. ROEBER, PH. D. Editor and Secretary
C. E. WHITTLESEY. Treasurer

Yearly subscription price for United States, Mexico and
United States dependencies, \$2.00; for all other countries, \$2.50
(European exchange, 10 shillings, 10 marks, 12.50 francs).

Copyrighted, 1908, by the Electrochemical Publishing Co.

Entered as Second-Class Matter, June, 1903, at the Post-Office at New
York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, FEBRUARY, 1908.

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The First Award of the Perkin Medal.

Quod felix faustumque sit. The Perkin medal, founded to commemorate the name of the inventor of mauve, and to act as a powerful stimulus to chemical research and invention, has been awarded for the first time. Mr. J. B. F. Herreshoff, vice-president of the Nicholas Copper Co. and consulting engineer with the General Chemical Co., is the recipient. Almost his whole professional life has been devoted to the furtherance of the interests of the leading chemical corporation of this country and thus indirectly to the progress of American chemical industry. Mr. Herreshoff's achievements in very diverse fields are well summed up in Dr. Chandler's felicitous speech, which will be found elsewhere in this issue. The secret of Mr. Herreshoff's immense success in his profession is to be found in a peculiar and exceedingly rare combination of mechanical engineering ingenuity with chemical science; as Dr. Chandler put it, he is an engineer by birth and a chemist by education—a typical chemical engineer, unsurpassed in his calling. The recognition given to Mr. Herreshoff by his fellow-chemists will give joy to all who believe that the future belongs not to the pure chemist, but to the chemical engineer. The selection of the man to be honored by the award of the first Perkin medal was not an easy one, and a great responsibility was thrust on the committee which made the reward. A number of brilliant names, dear to all American chemists and worthy of the honor, was before the committee, and it is a special pleasure to recognize what a prominent place electrochemical engineers took in this splendid array of names. It should be a matter of congratulation that for some time to come, at least, there will be no difficulty to find men worthy of the honor to receive the medal which bears the beloved name of the founder of the coal-tar industry.

* * *

When Mr. Herreshoff was unanimously chosen as the first Perkin medalist, the leading idea was that in him are incorporated those typical qualities which we hope shall be found in the typical chemical engineer of the future. The name "chemical engineer" is new. It expresses a new idea. Chemical engineers were not recognized in the past. When, through Mr. Carnegie's munificence, the "United Engineers' Building" came into existence, the chemical engineers were not remembered. And yet, after all, there is hardly any industrial development possible without the chemist. That the fault of this lack of recognition of the chemist has been in the past to a great extent with the chemist himself we all agree. That it will be different in the future we all hope. What may be expected of the chemical engineer of the future is exemplified in Mr. Herreshoff. And the award of the first Perkin medal to Mr. Herreshoff will act as a powerful incentive to the growing generation of chemical engineers.

A Mining Technology Branch of the United States Geological Survey.

In the last message of President Roosevelt to Congress the establishment of a Bureau of Mines was recommended as follows: "A Bureau of Mines should be created, under the control and direction of the Secretary of the Interior; the Bureau to have power to collect statistics and make investigations in all matters pertaining to mining, and particularly to the accidents and dangers of the industry. If this can not now be done, at least additional appropriations should be given the Interior Department to be used for the study of mining conditions, for the prevention of fraudulent mining schemes, for carrying on the work of mapping the mining districts, for studying the methods for minimizing the accidents and dangers in the industry; in short, to aid in all proper ways the development of the mining industry." In connection with this movement, looking to the further recognition of the mining industry by the Federal Government, the Senate Committee on Mines and Mining has recently requested the Director of the United States Geological Survey to present his views on the subject. Mr. Smith's report, transmitted to the committee, contains some interesting and important points, to which we wish to call attention.

* * *

The beginnings of Federal investigation of mineral resources are traced back to the early part of the last century, when Lewis and Clark were instructed to pay special attention to the geology and mineral resources during their exploration work. The explorations and surveys which were continued during the first half of the nineteenth century were further recognition of the duty the Federal Government owed the people in making known the resources of the great unexplored western half of the continent. These explorations were particularly actively pushed after the discovery of gold had focussed public attention on the mineral wealth of the trans-Mississippi region. While the results of these various surveys were of inestimable value to the development of the mining interests of the regions which they covered, yet there was lack of co-ordination and an absence of a comprehensive plan covering the entire field. Moreover, it had not yet been recognized as the province of the Federal Government to investigate the resources of the entire national domain, and not simply those of the public lands. In 1866 a more direct attempt was made to aid the mining industries by an appropriation which authorized the Secretary of the Treasury to "collect reliable statistical information concerning the gold and silver mines of the Western States and Territories." Though this investigation received very inadequate financial support, yet the results obtained by Dr. R. W. Raymond were of the utmost value to the mining interests. When, in 1879, the United States Geological Survey was authorized by Congress, all other Federal surveys of a similar character were abolished, and the office of Commissioner of Mineral Statistics under the Treasury Department also lapsed. The organic law provided that the director of the Geological Survey "shall have the direction of the Geological Survey and the classification of public lands and examination of the geological structure, mineral resources and products of the national domain." It is to be noted that this authorization, besides providing for geologic investigation, also

directly authorizes the study of mineral resources and the products of the national domain.

* * *

As a matter of fact, the work of the Geological Survey in the past has not been rigidly restricted to geologic investigations, but its directors have taken a broader view of the functions of the Survey, being, of course, limited by the appropriations granted for the work. Mr. Smith points out that while it might be held that the organic authority granted the director, as quoted above, is sufficient for any extension of the mining work, yet, in view of the present well-warranted demand for expansion of such mining work, it seems advisable to secure from Congress specific authorization for these investigations. But, in adequately providing for an increase in the mining work by the Federal Government, care should be taken not to duplicate what is already being done by the Geological Survey. In Mr. Smith's opinion, the whole question resolves itself into that of making adequate provision for the work now conducted by the Technologic Branch of the Geological Survey. These investigations have proved their value, and their scope may well be expanded along technologic lines without duplicating or overlapping the work of other branches of the Survey. The name of the new organization should indicate the restrictions of its functions; it should not be broadly a "mining" bureau, but a "mining technology branch." Director Smith's recommendation is, therefore, either to establish by law a "mining technology branch of the Geological Survey" or an independent "Bureau of Mining Technology," to which the work now under the Technologic Branch of the Geological Survey could be transferred.

* * *

It is open to question whether the surprisingly rapid growth of the Federal Government's ubiquitous activities is really healthy. We are quite sure that if all the recommendations of the functions of the new bureau contained in President Roosevelt's message were carried out, more harm would result than good. For instance, the recommendation to provide "for the prevention of fraudulent mining schemes" is excellent in its intention, but it is hard to see how this can be realized by the new bureau without interfering improperly with sound and legitimate mining enterprises. President Roosevelt's summary of the proposed functions of the new bureau—"in short, to aid in all proper ways the development of the mining industry"—is so broad that it really means nothing. The extension of the scope of the work of the Geological Survey so as to include technology is sound and feasible. But if it is carried out it is of the very greatest importance to prevent any possible friction with the Geological Survey, on the excellent work of which in the past this country may be proud. The safest solution would probably be to establish a Mining Technology Branch of the Geological Survey.

◆◆◆

The Chinese Iron Industry.

Much comment was heard last year when 2,500 tons of basic pig iron and later several lots of foundry and pig iron were shipped from China to the United States. It was an exceedingly curious and rare occurrence, quite the opposite of typical. It is not without interest to inquire how it was commercially

possible and practical to make those shipments almost half around the globe, pay a duty of \$4.00, and sell the iron in the greatest iron-producing country. Two facts which represent two different sides of the answer are clearly evident: one is the cheapness of shipping by water, the other is the cheapness of Chinese labor. Our readers will find some interesting facts concerning the Chinese iron industry in our present issue in an article of Mr. Blauel, who was formerly connected with the one large Chinese iron and steel plant. To expect competition in this country from the Chinese and Japanese iron steel producers would be ridiculous. But whether the Orient, with its immense natural resources of iron ore and coal in China and with the push and energy of the Japanese, might succeed in getting independent of the American and European iron and steel industry, is a more debatable question. It is not impossible if there really will be a Chinese renaissance, though it seems not very probable at the present time, when we read Mr. Blauel's story of the troubles of the Hanyang Iron & Steel Works, and consider that these troubles were due to the apparently inherent nature and business methods of the Chinese.



Machinery for Chemical Engineering Work.

The article by Dr. Oskar Nagel in our present issue, on machinery and apparatus for melting, heating, dissolving and eluting, is intended to open a serial on the most important machinery, apparatus and devices used in chemical engineering work on a large commercial scale. While the ideal chemical engineer should be a born and trained mechanical engineer, besides being a born and trained chemist, the ideal will be realized only in exceedingly rare instances. But every chemist who has the ambition to become more than a pure analyst, should be fully acquainted with the construction and operation of such machinery and apparatus which are now available for use in chemical works. There is a most essential difference between laboratory work and commercial work on a large scale. In the laboratory the question of cost of the process is almost insignificant; in working on a large scale it is of fundamental importance. Naturally, the machinery and apparatus used in the laboratory and in large chemical works must be very different. In view of the fact that all printed information available in this country on chemical machinery for large-scale operation is scattered throughout various journals and publications of manufacturing companies, we hope that the serial which we start in this issue will prove useful to many.



Weathering the Storm.

The business recession, still marked and unpleasant—in spite of gradually returning confidence in the financial conditions of this country—was expected by all shrewd and cold-blooded observers, but its severity in its acute stage was greater than even the most Cassandra-like prophets foretold. Things in the United States have been “on the boom” with but little breathing spells for nearly ten years. This great expansion caused increases in prices of all commodities and of labor and raised the rate of interest to an extremely high level.

Moreover, the efficiency of the workingman and all business was decreased because of the overload. Several things jarred the unstable equilibrium and business reacted. Our rigid and unscientific currency system, the anxiety of a pre-presidential year and social unrest were contributory, but the reaction would have come some time anyhow. Retrenchment and economy are now the order of the day. Laborers are seeking jobs all over the country, instead of the jobs seeking them. Consequently in certain parts of the country wages have been lowered. This is a healthful sign. While we wish to the workingman his fair share in the distribution of wealth, nevertheless the share he demanded previous to the panic, and often seized, was excessive and unfair. We argue high wages for efficiency, but not for inefficiency. The profits of all forms of industry must be reduced. Inefficient plants will be closed. Instead of national extravagance being the order of the day, it will be fashionable to economize. All the time the country will be growing richer, because, though the production of useful articles will be reduced, yet the consumption of these for useless purposes will be decreased, and the annual increment to our real national wealth will be increased. This is as true to-day as it was in the times of Adam Smith. Interest rates will be lowered, and consequently high-grade bonds tend to enhance in value. While this drastic stopping of economic extravagance will not be liked, yet it is a chastening process.

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The indications are that this process will not long continue in America. One reason for this is the curtailment of production of all commodities, especially the metals and their metallic products. The accumulated stocks of these were not abnormally large last Autumn. The partial control of industry in the group of powerful interests in New York will prevent accumulation of commodities to any great degree. For instance, the copper production of the United States, Mexico and Canada is reported as considerably less than in 1906. This, aided by extremely large exportations, is bringing copper into a stronger statistical position. The Steel Corporation, controlling now such an important portion of the pig iron production of the country since its purchase of the Tennessee Coal & Iron Co., is banking a large portion of its furnaces.

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Furthermore, the agricultural West is in good shape with large crops. In fact, it is stronger financially than the East. In 1893, on the contrary, poor crops in a new and unsettled community, with low prices for cereals abroad, had placed the West in a weak position. Finally production of useful commodities is much more efficient now than in 1893, due to the advance of modern scientific methods. It is a case of the survival of the commercially fit. And those plants will live which have been laid out along sound lines. In short, the industry of this country is not in such bad shape as the pessimists would believe. The storm which is still beating strongly on us will leave, when the country weathers it, but little wreckage. For some time, however, most people should work more and spend less. It is rather a pleasant habit when once acquired. For it is none the less true, if it were not so simple, that most things are acquired by a frugality of one's powers and persistence rather than by a burst of enthusiasm and a sprint of success.

The Iron and Steel Market.

The great improvement in the financial situation has produced increased confidence throughout the iron and steel trade, but of actual improvement in demand there has been none.

Production of pig iron during January has been about 35 per cent of normal, and production of steel about 30 per cent of normal. This is an increased rate compared with the holiday week but a decrease when compared with the early part of December.

Buying of finished steel products has been purely of a hand-to-mouth character, and has not been sufficient to maintain the rate of production, the latter depending more upon the filling of old orders on which shipment was not suspended. The augury is for some further decrease in production in the near future.

The consuming trade is not greatly interested in the matter of prices at present. There is very little business which would be placed in any event. Producing interests have been working in greater harmony than has ever before been witnessed to maintain prices on finished steel products, but not, as seems to be assumed in some quarters, with the idea that these prices should be maintained indefinitely. On the contrary, producers feel that there should be reductions ultimately, but they do not think the present is an opportune time. They wish, for one thing, to give such a demonstration of strength that when prices are reduced there will be confidence in the new schedule, and besides this they feel that a reduction made now would have to be followed by another later. Whatever statements may be made openly, it is safe to assume that the maintenance of former prices on finished steel products is an evidence that in the inner circles it is not believed that the situation is ripe for a material improvement in demand. It may not be safe to assume the converse is true, that when a general reduction is made it will be evidence that it is believed in the inner circles that conditions are conducive to an important revival.

In the movement which was inaugurated at the Gary dinner on Nov. 20, sub-committees of producers have been appointed in all the important finished steel lines. These committees have been doing missionary work with the view of having prices maintained, and it is the spirit of the times to regard the work as eminently successful, inadequate consideration being given, possibly, to the obvious fact that no serious temptation has arisen to cut prices; that millions of tons of finished steel orders are on the books, awaiting shipping instructions, with the clear prospect that cutting would demoralize the market and write an enormous depreciation upon the value of these orders.

PRICE CHANGES.

On Jan. 6 new prices on tin plates and sheet products became effective, the reductions having been formulated by the leading interest and submitted to a meeting of the independents in Pittsburgh. These reductions were:

Twenty cents a box on tin plates, to \$3.70 for 100-pound cokes.

Ten cents per hundred pounds on black sheets, to \$2.50 per hundred pounds for No. 28 gauge.

Twenty cents per hundred pounds on galvanized sheets, to \$3.55 per hundred pounds for 28 gauge.

Five cents per hundred pounds on blue annealed sheets, to \$1.80 per hundred pounds for No. 10 gauge.

Ten cents per square on painted corrugated roofing, to \$1.75 per square for 28 gauge, 2½-inch corrugations.

Fifteen cents per square on galvanized corrugated roofing, to \$3.10 per square for No. 28 gauge, 2½-inch corrugation.

These prices are all f. o. b. Pittsburgh in carload or larger lots, subject to a rebate of 5 cents per box, hundred pounds or square, under certain conditions; terms, 30 days net or 2 per cent off for cash in 10 days.

These reductions were prompted chiefly by the declines* in tin and spelter, such declines being more than sufficient to cover the total reductions made in the coated product. It had been hoped that the tin plate reduction would greatly stimulate buying, but the result has been rather disappointing. There has been a material improvement in buying, but as the coming season is near at hand it is doubtful if this improvement would not have occurred in any event. At the close of January the leading interest was operating about 154 of its 242 tin mills, against an average of about fifty during November and December. The independents, who have about 30 per cent as many mills as the leading interest, have been operating in about the same proportion.

There has been a slight increase in buying of sheet mills products, where but little improvement was looked for.

ORE PRICES.

There has been a demand on the part of some furnace interests that prices for Lake Superior ores for the coming season should be announced at once, some of these interests contending that the situation calls for a heavy reduction. The ore interests long ago reached the conclusion that in no event could any large demand be expected for ore this season, and that the condition was opportune to have an off season and get labor in a less intractable mood. They now contend that any reduction in ore prices would write a depreciation on the ores brought down last year and owned by the furnaces themselves. With full production the furnaces provided themselves with ore to lap over the opening of navigation in April, and with the decreased consumption some ore piles may last into August or September. At this writing it appears probable that ore prices will be named within a few days, at substantially the 1907 basis, which was \$5.00 for old range Bessemer, \$4.20 for old range non-Bessemer, \$4.75 for Mesabi Bessemer, and \$4.00 for Mesabi non-Bessemer.

PIG IRON.

The movement in pig iron has been small, but rather large in view of the general stagnation, and larger than was generally credited at the time the sales were made. A considerable tonnage of pig iron has been sold at inside prices, the buyer not soliciting competitive bids, but accepting a price from a single producing interest which was from \$1.00 to \$1.50 below the currently accepted market. Some 30,000 tons or more of Southern iron was sold at \$12.00, Birmingham, while at the close of the month the producers insist that the market is \$13.00 or \$13.50. The central Western furnaces have been quoting \$17.00 at furnace for No. 2 foundry, but a few have sold at \$16.00. Basic has been available at \$16.00 at furnace and Bessemer at \$17.

The Southern furnace interests, being self-contained, have been better able to meet the situation than the majority of Northern furnaces, which must buy ore and coke at prices involving good profits to the sellers, so that Southern iron has pushed farther into Northern markets than in the recent past.

STEEL.

Prices on billets and sheet bars have been firmly maintained at \$28.00 and \$29.00, respectively, f. o. b. Pittsburgh, but with very light transactions. While these prices are rather high, compared with the reduced prices on pig iron and scrap, it is desired to keep crude steel in line with finished steel.

FINISHED MATERIAL.

The wire interests under date of Jan. 13 announced to the trade that there would be no reductions on wire products for the spring trade. This was interpreted by the trade as a guarantee, and a moderate increase in business has resulted.

A little new structural business has been coming up now and then but has not amounted to one-third the normal.

Plate business has been light, and some of the smaller mills

are shading the recognized market of \$1.70 by \$2.00 or so per ton. The steel car interests are working on the tail end of their orders, and will probably run out in February, with no prospect of additional orders of consequence.

Iron bars have, as usual, yielded to poor demand and a lower scrap market rather promptly. They have fallen, in different markets, by from 25 to 40 cents a hundred pounds as compared with the prevailing market in October, and are now on the basis of about \$1.35, Pittsburgh, for Western shipment and on a lower basis than this for Eastern shipment. Steel bars are nominally held at \$1.60, the old price, but it is certain that no such basis can be maintained in view of the iron bar situation, and a readjustment in steel bar prices appears merely to await an appearance of actual demand.

COKE.

Contrary to expectations which were entertained in December, the leading Connellsville coke interest immediately after the first of the year announced a reduction in wages, reducing mining and loading room and rib coal from \$1.35 to \$1.20 per 100 bushels, and other rates in the usual proportions, thus practically restoring the scale which prevailed from March 1, 1905, to March 1, 1907. The lowest scale since the early part of 1899 ruled from Dec. 16, 1903, to March 1, 1905, the mining rate being \$1.10. Very little is being done in contract coke; nominal prices for standard Connellsville 48-hour coke are \$1.80 to \$2.00 for spot and \$1.90 to \$2.10 for contract, 72-hour coke being \$2.35 to \$2.50.

Chicago Meeting American Chemical Society.

The thirty-seventh general meeting of the American Chemical Society was held in the Kent Chemical Laboratory of the University of Chicago, Dec. 31, 1907, to Jan. 3, 1908.

On Tuesday morning the American Chemical Society was called to order and the following addresses were delivered:

"The Application of Physical Chemistry to Organic Chemistry." Julius Stieglitz, chairman of Organic Section.

"The Hydronitrogens and Their Derivatives." A. W. Browne, chairman of Inorganic Section.

These addresses were followed by section meetings.

In the afternoon, at 2:30, Clifford Richardson, retiring chairman of Section C of the A. A. S., delivered an address, entitled "A Plea for the Broader Education of the Chemical Engineer."

Following this address there was held a special meeting of the Industrial Section, which was well attended, at which the report of the committee on industrial journal and organization of an industrial division was made a special order. The report was discussed at length, and by vote of the section was unanimously and enthusiastically approved by the members present. It was decided to establish a "Division of Industrial Chemists and Chemical Engineers," which shall elect its own officers, and to establish a Journal of Industrial and Engineering Chemistry, covering the whole field of chemical industry, with a Board consisting of an Editor-in-Chief, who shall be a member of the Council, and of twenty-five editors, each an expert in some special field.

In the evening at 8 o'clock, a complimentary smoker to the visiting chemists was given by the local section and some three hundred chemists were present.

On Wednesday, Jan. 1, the Society was called to order in general session, and the reports of committees were made. Marston T. Bogert's re-election as president, and the election of H. P. Talbot, Louis Kahlenberg, Albert E. Leach, Wm. D. Richardson and W. Lash Miller as councilors-at-large were announced.

The meeting then listened to addresses as follows:

"Some Present Day Problems of Biological Chemists." R. H. Chittenden, chairman of Biological Section.

"The Passage of Substances Into the Human System by Osmosis." Louis Kahlenberg.

Following these addresses meetings of the sections were held in adjoining rooms.

In the afternoon, excursions were taken to the Illinois Steel Co., Chicago Gas Light & Coke Co., By-Products Coke Corporation, American Smelting & Refining Co. and the American Linseed Co.

In the evening, President M. T. Bogert delivered his presidential address, entitled "American Chemical Societies," at Fullerton Hall, Art Institute.

On Thursday morning, addresses were made in general session as follows:

"The Non-Equivalence of the Four Valences of the Carbon Atom." J. U. Nef.

"The Chemical Education of the Engineer." Wm. H. Ellis, chairman of Industrial Section.

"Chemistry in the Government Service." W. D. Bigelow, chairman of the Agricultural, Sanitary and Food Section.

"The Inter-Relations of the Elements." Herbert N. McCoy, chairman of Physical Chemistry Section.

Following the general session, meetings of the Sections were held throughout the day.

In the evening at 7 o'clock, the annual subscription dinner was held in the banquet hall of the Auditorium Annex, and was attended by over two hundred chemists and their friends.

On Friday morning, the Inorganic Section finished its program, and in the afternoon, excursions were taken to Swift & Co.'s packing plant, where a complimentary lunch was served; also to Libby, McNeill & Libby's, to the White Lead Co. and to the Standard Oil Co.

Over three hundred and fifty chemists attended the meeting, which was enjoyed by all. The announcement of the rapid and continuous growth of the American Chemical Society, which has now a grand total of 3,567 on its roll, and the plans for special development of its Industrial Section into a Division of Industrial Chemists and Chemical Engineers, with the publication of a Journal of Industrial and Engineering Chemistry, was met with strong approval.

The program of the papers presented before the different sections was as full as usual, their number being not less than ninety, besides the general papers mentioned above. We can mention here only a few. Before the Section of Inorganic Chemistry, J. R. Withrow discussed the influence of temperature on the electrolytic precipitation of copper from nitric acid; C. James, a scheme for the separation of the rare earths; C. R. Sanger, the preparation of silicon tetrachloride. Before the Section on Physical Chemistry, E. P. Schoch spoke on the heat of ionization and the reversible potential of nickel; W. D. Bancroft, on the casting of zinc; C. L. Parsons, on solution in a dissolved solid; J. W. Turrentine, on "reversed electrolysis."

The following papers were presented before the Section of Industrial Chemistry (Wm. H. Ellis, chairman):

W. D. Richardson, "The Criteria of Deterioration in Flesh Foods."

W. D. Richardson, "Transparent Soap: a Supercooled Solution."

C. H. Herty and W. S. Dickson, "The Volatile Oils of Pinus Tæda and of Pinus Echinata."

C. H. Herty and F. B. Stein, "The Use of Carbon Tetrachloride as an Extractive in Commercial Analyses of Cotton Seed Meal."

D. T. Day, "The Examination of Crude Petroleum for Comparative Purposes."

J. E. Teeple, "Long Leaf Pine Oil."

Alfred H. White, "The Microscopic Detection of Free Magnesia in Portland Cement."

W. C. Geer, "The Composition of Wood Turpentine."

W. D. Harknis, "The Deposition of Arsenic upon the Vegetation of Smelter Regions."

American Electrochemical Society.

At the meeting of the board of directors, held in New York on Dec. 27, the following gentlemen were elected members: Dr. Lars William Ohlman, University of Finland, Helsingfors, Finland; John L. Polk, Rensselaer Polytechnic Institute, Troy, N. Y.; Dr. Kamejiro Yoshikawa, professor of electrochemistry, Imperial University, Kyoto, Japan; Walter C. Smith, A. C., United States Metals Refining Co., Chrome, N. J.; John B. Lewis, University of Texas, Austin, Tex.; W. H. Erhart, vice-president, Charles Pfizer & Co., New York City; Robert H. Hartley, Hartley Building, Pittsburg, Pa.; Hugo J. Wichmann, United States Food & Drug Inspection Laboratory, St. Paul, Minn.; Herbert A. Baker, American Can Co., Paulsboro, N. J.; Meyer Schamberg, chemist and mining engineer, Philadelphia, Pa.; Wilbur F. Hurlburt, American Electric Furnace Co., New York City; Johan Winsnes, Vadheim Elektro-Chem. Fabrik, Vadheim, Sogne, Norway; Frederick V. L. Hiorth, electrochemical engineer, Christiania, Norway; Lewis E. Saunders, Norton Emery Co., Niagara Falls, N. Y.; James M. Neil, technical chemist, Toronto, Can.; Dr. Franz H. Hirschland, manager, Goldschmidt Chemical Co., New York City; Arthur B. Lamb, associate professor of chemistry, New York University, New York City.

At the meeting of the board, held in Philadelphia on Jan. 28, the following gentlemen were elected members: J. Robert McFarlin, electrochemical engineer, Electric Service Supplies Co., Keokuk, Ia.; Jas. Aston, manager, Thos. Aston & Son, Milwaukee, Wis.; George E. Long, University of Wisconsin, Madison, Wis.; Rudolf Albrecht, The Sun Co., Marcus Hook, Pa.; George R. Kendall, McGill University College, Vancouver, B. C.; Edward Zarembo, manager, American Foundry & Machine Co., Chicago, Ill.; Otto Mantius, American Foundry & Machine Co., Chicago, Ill.; Johan Fr. Irgens, managing electrical engineer, Technisk Bureau, Ltd., Bergen, Norway; Walter H. Aldridge, consulting engineer, Canadian Pacific Railway, Trail, B. C.

International Electrical Exhibition in Marseilles.

An international exhibition of the Applications of Electricity will be held this year in Marseilles, France. It will be opened to the public on April 19, 1908 (Easter Sunday), and will be closed on Oct. 31.

The town of Marseilles, the population of which exceeds 500,000 inhabitants, has now acquired a perfect system of distribution of electrical energy. Furthermore, the entire south-east district of France, which hitherto received its electrical supply from a number of small power stations, will now enjoy the advantages of a vast system of distribution of electrical energy, consisting of a series or ring of hydro-electric generating stations, which when completed, with reserve stations, will have a total capacity of 150,000 hp. Eight departments, including 400 districts, and representing a population of more than 3,000,000 inhabitants, are, or will shortly be, supplied with electricity by this system of distribution.

As a result of these conditions the inauguration of an International Exhibition of the Applications of Electricity, to take place in Marseilles in 1908, has been suggested as a most desirable means to bring to the attention of the general public the numerous possible applications of electricity all grouped together in one general exhibition, and to establish new commercial relations in this vast area, and thus make possible its rapid development by the substitution of new methods for old ones.

The town of Marseilles, recognizing the great possibilities of such an undertaking, has placed the magnificent park of the "Rond Point du Prado" at the disposal of the committee. This park, with a superficial area of 60 acres, was, in 1906, the site of the brilliant and successful French Colonial Exhibition,

and lends itself in every way to the object in view by reason of its facility of access, shady avenues, its "Grand Palais" and its general situation and surroundings.

The existing buildings will be supplemented by a number of new ones, and extensions will be made wherever they will be found desirable to fully meet the requirements of the exhibition.

The exhibition will comprise the following principal sections, which will be further sub-divided into classes:

1. Transmission and Distribution of Electrical Energy.
2. Applications of Electricity to Industries in General.
3. Applications of Electricity to Domestic Industries.
4. Applications to Domestic Economy.
5. Applications to Public and Private Lighting.
6. Applications to Heating and Ventilation.
7. Applications to Machinery for Lifting and Manipulation.
8. Applications to Mines and Quarries.
9. Applications to Traction.
10. Applications to Agriculture.
11. Applications to Military and Naval Engineering.
12. Electrochemistry, Electrometallurgy and Allied Arts.
13. Telegraphy and Telephony.
14. Applications to the Medical and Surgical Sciences.
15. Electrical Instruments for Measurement and Calibration.
16. Raw Materials and Manufactures Used in Electrical Industries.
17. Practical and Theoretical Teaching of the Science of Electricity.

Since the special purpose of the exhibition is the demonstration of the applications of electricity, it does not include a section for the "generation of electricity," but manufacturers will be allowed to exhibit plans, photographs and models of machinery built by them and of generating stations executed under their contracts.

Arrangements have been made by the committee to supply exhibitors with electrical energy, including direct and alternating currents at various voltages and frequencies.

The rules and regulations of the exhibition, including a complete list of the members of the different committees, the rates for space and stalls and the supply of electricity, together with a list of awards, will be forwarded on application to the commissioner for the United States, Mr. Paul Dény, Park Row Building New York City.

CORRESPONDENCE

A Modification of the Induction Furnace for Steel Refining.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—The article by Prof. H. Wedding in your January issue on the Roehling-Rodenhauser modification of the electric induction furnace for steel refining is very interesting, though it seems questionable to the writer whether this modification will meet with much favor.

In the past few years we have heard much about the induction furnace, and have always been told that its chief advantage consists in the absence of all electrodes which could contaminate the molten metal. Now come Messrs. Roehling and Rodenhauser and make a combined induction and electrode furnace. Do they not thereby give up voluntarily the one big chief advantage of the Colby-Kjellin design?

The use of refractory oxide material (such as used for the filament of the Nernst lamp) for electrodes seems ingenious and the writer expects to hear more of it in future for certain work. It needs, of course, preheating in some way to become a conductor. In this present case this is accomplished by the charge, first heated by pure induction currents.

PITTSBURG, PA.

M. M. B.

The Perkin Medal and its First Award

The meeting of the New York Section of the Society of Chemical Industry, held at the Chemists' Club on Jan. 24, was devoted to the presentation of the first Perkin Medal to Mr. J. B. FRANCIS HERRESHOFF.

The program of the evening consisted essentially of two parts. In the first half, after the introductory remarks of the chairman and secretary, different branches of chemical industries were discussed by several speakers from different viewpoints in a general, broad way. The second half of the program consisted of the presentation of the Perkin medal to Mr. Herreshoff through Dr. Charles F. Chandler, Mr. Herreshoff's reply, and concluding remarks by Dr. William H. Nichols. While an account of Mr. Herreshoff's brilliant professional achievements as a chemical engineer will be found below in Dr. Chandler's speech, we will give here concisely the chief data of his life.

Mr. J. B. Francis Herreshoff was born in Bristol, R. I., and is a brother of the well-known yacht designers and builders. He received his college education at Brown University, and in 1870 became assistant instructor in chemistry for two years. After that he was chemist with Prof. Charles A. Seely, in New York, and then chemist for the Silver Spring Dyeing Establishment, and chemist with William M. Habbershaw, at New York. In 1875 he was made superintendent of the Laurel Hill Chemical works of G. H. Nichols & Co. In 1890 he was made vice-president of the corporation of the Nichols Chemical Co. In 1900 he became vice-president of the Nichols Copper Co. and consulting engineer with the General Chemical Co. He still occupies these positions.

Chairman GEORGE C. STONE, in calling the meeting to order, pointed out that the evening marks an epoch in the history of the section. The Perkin medal is to be given to an American chemist as a recognition for good work done. Sir William Perkin

was primarily a scientist, a chemist, but he proved equally great as an inventor, and as an engineer in reducing his invention of the first coal-tar dye to a commercial scale and in financing his commercial work. Any man who will succeed equally well in only one of these different lines deserves our recognition. In Mr. Herreshoff, as the first to receive the Perkin medal, we admire a man of broadest engineering ability and of success in many fields.

Dr. HUGO SCHWEITZER then gave a history of the Perkin medal and presented the report of the committee for its presentation. He spoke in eloquent words of the development of the coal-tar industry and its effect on chemical science and of the Perkin celebrations in London and New York in 1906. On that occasion the New York Section of the Society of Chemical Industry decided to commemorate Sir William Perkin's name in two ways, by the foundation of the Perkin Library at the Chemists' Club and by the foundation of the Perkin research gold medal. The Perkin medal committee held its first meeting on Dec. 16, 1907. The names of a number of highly distinguished American chemists worthy of the

honor were before them. The committee unanimously selected Mr. J. B. F. Herreshoff as the typical American chemical engineer to be the first recipient of the Perkin medal.

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Prof. M. T. BOGERT spoke on the stimulus given chemical research and invention by suitable recognition.

While the conscience of having done something worth while is the finest reward a man can have, public recognition should come too. It acts as a stimulus, as an incentive to do more. The victories of a chemist are often spoken of as victories of peace, but victories of peace are not always peaceful victories. Like the soldier, the chemist has to face many dangers in his research. Even the greatest and most careful chemists have to face this danger. Bunsen lost the sight of one eye. ("Even in such harmless research as food chemistry it sometimes happens at the most unexpected moment that the food chemist himself will explode.") American chemists have now the Nichols medal and the Perkin medal as a stimulus. The presentation of the medal to a man means the approbation of his work by his fellow chemists and fellow scientists. The true philosophical mind works not for gold. He seeks science, which is more precious than any gold.

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Mr. H. A. METZ (the present Comptroller of New York City) spoke on the services rendered by the chemist in the development of the coal-tar industry.

In taking a broad view of this subject he pointed out that in giving an account of the services of the chemist in the industry, or better, industries originating in the utilization of the various products contained in the substance known as coal-tar, it is necessary to give a complete history of these industries. It is impossible to separate in any way the scientific and the commercial development, as they are so closely interwoven in the advance made in the manufacture of the various products, whether coloring matters, medicines, technical products or raw materials. The whole displays a system of evolution which

we can appreciate more thoroughly than those in some other branches of science, as we have before us the visible results of each step forward in working out the possibilities of the application of trained scientific knowledge to the problems of these industries.

Mr. Metz traced, in a concise sketch, the development of the industry from the early days of Perkin and Hofmann. He showed how the dye-stuff industry was in the beginning located principally in England, as the names of the new colors which appeared from time to time proved; but owing to the advance of technical education in France and later in Germany it soon passed to these countries. The greatest recent development, as a result of chemical research, is the manufacture and sale of synthetic indigo, the research beginning in 1880 (Baeyer). Carl Heumann in 1890 tried to use a different starting point. The different big German chemical companies took this research up and carried it to final success about 1896. But at that time the most promising method, that of the production of indigo from benzene, as indicated by Heumann, was still impracticable, on account of the unsatisfactory



J. B. FRANCIS HERRESHOFF.

yields. J. Pflüger discovered that the addition of sodium amide increased the yield sufficiently to make this process of Heumann's the most satisfactory and successful method for the synthetic production of indigo, and it is this process which is now generally used.

The synthetic indigo, is now almost exclusively used by the large manufacturing countries of the world, the total consumption of the United States for the year being equivalent to 1,500,000 pounds of 100 per cent indigotine.

While the manufacturers were developing the coal-tar dye-stuff they were not idle in other lines, as the list of medicinal chemicals derived from coal-tar shows. Some of the older ones, as antipyrine, acetanilide, phenacetine, "have become so popular as to claim even the attention of the United States Government," but these are only a few of the total number.

This whole development is undoubtedly due to the services rendered by the chemist. Germany has recognized this, and some of the large German companies employ 200 or more research chemists on their staff. "The manufacturing establishments in the United States have begun to employ chemists more and more in their works, and we are here to-night to present this medal which is given as a reward of their labors in this field. If this spirit is encouraged and the use of scientific knowledge increased, the manufacturing interests of the United States will at last take their proper position among the other nations of the world."

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Prof. SAMUEL A. TUCKER spoke on **electricity as applied to industrial chemistry**. The more extensive use of electricity for power purposes in chemical engineering makes it necessary for the chemist to keep abreast of the times and be familiar with the advance of electric power as applied to his own industry. But with the utilization of electricity to produce chemical effects, industrial chemistry is even more deeply concerned, and the industrial chemist or engineer requires at the present time a very broad training in order to fit himself for the many diverse lines with which he may become connected.

The possibilities of electrolytic refining and of electrolytically making substances practically chemically pure in one operation immediately put a premium on the electrolytic article. Such chemicals as caustic soda and cyanide and electrolytic copper may be taken as examples. Metals such as aluminium and calcium and compounds like the persalts are alone possible by electrolytic means. For the purely thermal reactions the use of electricity is particularly advantageous, as a result of the particular features of the electric furnace.

Prof. Tucker remarked how very striking it is to note the rapid introduction into everyday life of material that was quite unknown not so long ago or regarded as a chemical curiosity, and carefully preserved in museums. Carborundum, artificial graphite, silicon, aluminium and acetylene have become such every-day matters that they no longer occasion any remark, but we can all remember when we had none of them.

The high temperature of the electric furnace opens up many new lines of investigation, and one, particularly, of which very little is known. This is the change of state or allotropic modifications that are possible by change of temperature. A piece of lime treated in the electric furnace is thereby changed into crystals of definite form. But the crystalline lime bears little or no resemblance to the ordinary variety except in chemical composition. It no longer slakes in water, even after standing for several days, and can be boiled in hydrochloric acid without action. There are other instances of this phenomenon, but the reason for such a change is not known. We speak of crystalline form, but of the real nature of crystals we probably know as little as of the real nature of electricity.

While the development of applied electrochemistry since the days of Davy and Faraday might appear at first sight to have been slow, we must remember that the electric dynamo and motor had to come before electrochemical engineering

could begin. Prof. Tucker traced the rapid development of the last ten or twenty years, and paid attention to the very latest advances in the electrometallurgy of iron and steel and in the fixation of atmospheric nitrogen. He also spoke in most complimentary terms of Acheson's triumph in making delocculated graphite and entering the vast field of lubrication. "The systematic and clever way in which it was developed only adds to our admiration of its able inventor."

"Really, this ability to invent uses for an invention seems to be peculiar in the electrochemist. The new compound 'monox' seems to place Potter on an equal plane with some others in this respect, for the surprising things that are attributed to that interesting compound remind one of the probable patent claims that the alchemists would have included if patent offices had been in operation in those days."

Electrochemical engineering is peculiarly dependent upon cheap power. "Advantageous as it may seem to obtain power from Niagara the price is too high for the successful operation of many processes of an electrochemical nature, and this is due largely to the heavy outlay necessary for the engineering work which makes the interest charges so great that the price for power must be high. Apparently in this country we have few localities to compare in natural advantages with water-powers which may be found in Europe, and we have the additional disadvantage of high labor cost for the engineering work, so that water power for chemical industries forms in this country a less attractive proposition than at first seemed the case. The location of the available water-power also has a great influence on its usefulness, in connection with transportation facilities, and the proximity of raw material. High-tension power transmission is a help in this connection, but this also adds to the cost of power, which is too high already at the place where it is generated. The use of gas power is extending and will certainly have something to do with the advance in electric iron and steel production."

Professor Tucker concluded his interesting and suggestive speech with this remark: "Inventions come so fast that we are apt to think some problems impossible if they are not solved at once, but when the time is ripe we usually get what we want. It is, therefore, best for the present to content ourselves with such splendid advance as this last branch of chemical industry has had—an advance due to men of the stamp of the one we are honoring to-night."

* * *

Next on the program was a discussion by Mr. JAMES SPEYER, of **the chemical industry from the standpoint of the investor**. Mr. Speyer was unable to be present early in the evening, but arrived later and spoke at the session of the Verein Deutscher Chemiker, held after the official program of the evening was over. Though Mr. Speyer's remarks were informal they should be recorded here.

Mr. Speyer first stated that it was hard to discuss the chemical industry from the standpoint of the investor at a time when there were so few investors. Besides Perkin mauve we have now Wall Street blues. So far the chemical industry is very little known in Wall Street, and during the last months this has been a good thing for the chemical industries.

The lessons of the other industries which are better known in Wall Street will be learned, and this will turn out to distinct advantage of the chemical industry. Mr. Speyer concluded with a reference to that well-known fundamental chemical compound, H₂O, and the effect which it has in financing.

Presentation of the Medal.

Dr. CHARLES F. CHANDLER then presented the Perkin medal to Mr. Herreshoff with the following felicitous address:

"It is my privilege as the senior past president of the Society of Chemical Industry residing in this country, to make the actual presentation of the Perkin medal to our distinguished brother chemist, J. B. F. Herreshoff. It seems hardly

necessary, when speaking to an audience of chemists, to enter into any details with regard to Mr. Herreshoff's great achievements in the field of industrial chemistry, but in order to make a record for this occasion, I will take a few moments of your time to give you a brief sketch of some of Mr. Herreshoff's more important labors.

"The improvements and inventions of Mr. Herreshoff began in 1875 and have continued down to the present time—a period of over thirty years. From 1875-1890 he was associated, with the firm of G. H. Nichols & Co.; from 1890-1900 with the Nichols Chemical Co., and from 1900 to the present time with the Nichols Copper Co. and the General Chemical Co.

"During these thirty years of active industrial development, Mr. Herreshoff has applied his mind to a very great variety of chemical and metallurgical industries, and has perfected many most radical improvements that have assisted greatly in reducing the cost of production and improving the quality of the products manufactured by these companies.

"He has substituted scientific management for the old-fashioned rule of thumb in the conduct of all the operations which have come under his direction, and has thus developed the highest standard of factory control.

"At an early date Mr. Herreshoff devoted his attention to **copper smelting** and invented the well-known smelting furnace for this metal, which has long borne his name, and was patented in 1883. Prior to this date brick furnaces had been almost exclusively used and the separation of the matte gave very crude and unsatisfactory results. His furnace is steel-enclosed and water-jacketed with a movable fore-hearth or well, placed on wheels, so designed that the slag or the matte running out of the breast of the smelter must pass directly into the hole in the side of the well placed 8 inches or 10 inches below the molten mass that overflows from the opposite side of the well. In this manner the air blast is suitably trapped and coke is prevented from running into the well. The matte, after accumulating in the well, is tapped out from time to time.

"The success of this furnace became generally known and the steel water-jacketed furnace, with a movable well, is now almost universally employed, except where reverberatory furnaces for special reasons offer economical inducements.

"A number of these furnaces have been used in Canada in the Sudbury district for smelting nickel and copper ores. They are also used in the Ducktown district in Tennessee, in Mexico, and have been used for a long time at Laurel Hill.

"Later, Mr. Herreshoff directed his attention at an early day to the improvement of the **chamber process for manufacturing sulphuric acid**, and succeeded in developing the most advanced process that the world has ever seen—at least up to a short time since. In accomplishing this result his ingenuity was taxed in innumerable ways to provide the necessary apparatus with which to put his advanced ideas into practice.

"The atomizers devised by him for the injection of weak sulphuric acid into the chambers were a great improvement and at once reduced the steam consumption one-third. He succeeded in reducing the consumption of nitre to 1 per cent of the sulphur burned.

"He then devised the Herreshoff tower, which is a modification of the Glover tower, and is designed for denitration and for concentration. In place of the brick or self-sustaining walls of the Glover tower, finely crushed material (preferably quartz) is used, and the lateral pressure due to the interior filling or filter bed of the tower is resisted by suitable iron plates outside of the lead sides of the tower. This lining of fine material is thus held suitably in place and is prevented from passing or washing into the filter portion of the tower by an intermediate layer of quartz crushed to sizes from $\frac{1}{4}$ to $\frac{1}{2}$ inch. The filter bed is sustained by cross-bearers of quartz. The bottom is so constructed that it completely resists the action of very hot acid of very high strength.

"The great advantage of this tower is that its life is exceedingly long. It is nearly indestructible. In operation the heat of the burner gas is retained by having a non-conductor over the arch and this high temperature assists greatly in giving perfect denitration, although the acid is concentrated up to 63° or 64° Be. The acid coming from this tower is so free from iron and alumina that it is run directly into a platinum still or pan, and concentration is completed in another pan constructed of iron, the hot gases from the furnace passing directly under steam boilers. This invention effected a very great saving and has been in use from 1885, to the present time, in the earlier works of the Nichols Co. and in all those of the General Chemical Co.

"Herreshoff then developed an extremely ingenious apparatus for concentrating the sulphuric acid delivered from the Herreshoff tower. The hot acid from the improved tower is first concentrated to 65° in platinum. It is then run into an iron pan for concentration to over 66°. From this pan it runs into a large cast-iron pan, and while passing through it most of it is distilled off and condensed in a platinum Liebig's condenser to 66°. This acid is free from arsenic and otherwise very pure. The acid which passes through the stills without distillation represents a small proportion of the total and has a strength of 98 per cent. The amount of fuel used in the distillation is very small, on account of the small, latent heat of sulphuric acid of this strength. This improvement in the distilling apparatus came as the result of the increasing demand for a purer sulphuric acid than could be obtained by the ordinary methods of concentration. Dr. Lunge, the great authority on sulphuric acid, in his master-work on the subject, states that the claims Mr. Herreshoff made for his still were impossible. Nevertheless, at one single establishment 100 tons of distilled sulphuric acid were produced daily from pyrites, that compared favorably with the concentrated acid made from brimstone, satisfying the demands at the time for purity, at a price at which brimstone could not profitably compete.

"His almost indestructible Glover tower made it possible to concentrate the acid to a much higher strength than had previously been attained, and this in conjunction with the aforesaid stills produced practical results that in the stage of development then existing were almost revolutionary.

"Herreshoff's improvements in the Gay-Lussac towers were also very marked, enabling him to use enormous quantities of sulphuric acid in absorbing, while at the same time the elevation to which the acid had to be pumped was greatly reduced.

"His next invention was patented in 1896, and consists in an improvement on the original idea of the Gilchrist and Johnson type of **roasting furnace**; that is, a roasting furnace intended for **roasting fine iron pyrites ores**. Heretofore a great many roasters had been devised but none of them was satisfactory. Even the Gilchrist and Johnson furnace was a failure on account of inability to make repairs without completely shutting down the furnace, the arms being bolted solidly to the central vertical shaft. This bad feature was overcome by an improvement that made it possible to take out an arm whose teeth were no longer serviceable and replace it by a new one in 1 minute. A marked improvement in this furnace was made and patented by him in 1899.

"When this improved furnace was put on the market there were immense quantities of fines ore in various parts of the country that could not be sold on account of the inability to roast it, especially for sulphuric acid making, without great cost and trouble. This ore was used up very rapidly thereafter, rendering available, say, 3,600 tons a day of fines pyrites, which hitherto had been a kind of drug in the market. When one estimates that this means the production of more than 1,500 tons of sulphuric acid a day, he can see the importance of this furnace to that industry. There must be over a million tons of fines ore roasted in these furnaces annually, or enough to make approximately 2,000,000 tons oil vitriol per

The enormous accumulation of fines ores thus became almost as valuable as lump ore. These furnaces have not only been adopted in a large way by chemical works and fertilizer factories, but also for desulphurizing ores in connection with copper refining. Up to this time there have been sold 478 furnaces in the United States and 644 in Europe, making a total of 1,122 furnaces. Most of these are used for roasting pyrites fines ore in manufacturing sulphuric acid. They have a capacity for burning 3,000 pounds sulphur in 24 hours, and assuming that they were all used in the manufacture of sulphuric acid, the amount of acid produced as O. V. would be about 2,500,000 tons per year. They are still being sold quite extensively in Europe as well as in this country. They have been a great boon to the fertilizer industry of the United States, especially in the South, where most of the pyrites ore is in quite a fine condition when mined. They have also made possible the use of pyrites for the production of paper pulp in place of brimstone, because by their use a sufficiently rich gas can be produced.

"The next great work which Mr. Herreshoff undertook was the development of the **electrolytic refining of copper**, which was at that time practiced in a small way in two different works in the United States. His plan for electrolytic refining was entirely different from anything that had been devised before, or, as I believe, since. The electrolytic refining of copper was not at that time well understood. Even the analytical work necessary was quite inaccurate. The improvements and development which resulted from Mr. Herreshoff's study of the problem were only made possible by the highest scientific attainments and the aid of a corps of men thoroughly trained by him for the work. As a result he has created in the past ten years the largest copper refinery in the world which, in itself, is a clear indication of the fact that his processes have been eminently successful in the perfection of their results as well as in their pecuniary economies. The output of this refinery at the present time is about 1,000,000 pounds of copper per day, or about one-fourth of the world's entire output.

"In connection with this work, Mr. Herreshoff invented an apparatus for casting metal, used especially for the casting of the thin anodes employed in the series system for making electrolytic copper, which has brought about a large saving and which is very extensively used.

"Mr. Herreshoff's crowning achievement has been his work in developing the **contact process for the manufacture of sulphuric acid**. Taking the magnificent work of Dr. Knietzsch, as a foundation, and the splendid engineering work of the Badische Co., in Germany, Mr. Herreshoff, as the result of more than one thousand investigations, in which he was ably assisted by others, but which he directed, made that process not only adaptable to American conditions, which are quite different from those for which it was originally intended, but has also economized very much the whole cost of the operation, so that now the contact system is an established process in this country. It has made possible the production of sulphuric acid of the highest strength, including anhydrous sulphuric acid, at a lower cost than the old chamber system with the necessary concentrating plants in connection therewith, and now an acid virtually chemically pure can be supplied to the largest manufacturing industries in unlimited quantities at a lower price than previously known.

"In addition to the great achievements which I have already mentioned, there are many others. Mr. Herreshoff has produced almost a revolution in every chemical manufacture which he has undertaken, increasing the yield, decreasing the cost, and improving the quality of the products. One of the great secrets of Mr. Herreshoff's success is his ability to concentrate himself upon any given subject which he has in hand. It is impossible to make a catalog of the achievements of a great man.

"Mr. Herreshoff is an engineer by birth, and a chemist by

education. He is a typical chemical engineer, unsurpassed in this calling. It is eminently proper that he should be selected by the representatives of the great chemical societies of this country to receive the Perkin medal, which was founded a little more than a year ago in honor of the great chemist, who laid the foundations of the great coal-tar industries, which have had in the past fifty years such a profound influence, not only upon the chemical industries of the world, but also upon abstract chemical science.

"It gives me great pleasure as the representative of the Society of Chemical Industry and the affiliated chemical and electrochemical societies to place in your hands, Mr. Herreshoff, this beautiful token of the appreciation and affection of your fellow-chemists."

Mr. Herreshoff's Reply.

Mr. J. B. F. HERRESHOFF replied in a graceful and exceedingly modest speech. He remarked that to succeed in chemistry and its applications one must have great love for his work. He mentioned the words taught him by his old professor in Brown University, "You must love chemistry better than your own soul."

Mr. Herreshoff sketched the benefits which mankind has derived from inventors. In the early ages there was no patent office and no protection of the inventor, and inventions were naturally kept secret and progress was slow. But gradually distinct facts were brought out and they were then formulated into laws. Thus came science into the world. Inventions, improvements of processes, laid the foundation for what is now the glory of the world—science. As it is now, science pays back what it owes to the inventors. It is now impossible to carry out any invention without the aid of science—physical science, chemical science, engineering science. And in spite of all our progress Edison is probably right in saying that we are just only in the beginning and that invention is still in its infancy.

There are two classes of inventors. The first class comprises those who invent something from a theoretical conception, without understanding the difficulties. Their ideas fill the volumes of the patent office, and while most of their work is worthless, much is indirectly valuable for the world, since it acts as an incentive, so that others who understand the difficulties take up the matter again and improve on the imperfections. The second class of inventors are now chiefly connected with our great manufacturing industries. They observe carefully the difficulties which are to be overcome, and by gradual improvement they bring about the most valuable inventions.

Some of these inventions require very little experiment; they come suddenly from an idea. A mere thought brings about at once an important improvement. The Bessemer converter process with its immense commercial importance is an example. In Mr. Herreshoff's own work, when he had installed some roasting furnaces in the South, troubles arose with the shaft and the arms, and letters came and telegrams. This troubled him so much that he concentrated his thought completely on the necessity of making an improvement, and suddenly there came to him the idea of changing the construction to the one which is now so well known. In ten days the construction had been actually carried out, and the parts were on the way to the South. Since that time no further change has been necessary whatever.

In other inventions a great deal of experimenting is required for the development. In Mr. Herreshoff's experience this was specially true in the development of the contact system for making sulphuric acid, with its series of different stages and successive use of different apparatus: cooling of gases, purification of gases, drying towers, the blower, the contact apparatus producing SO₃ and the absorption apparatus. In the first three years of the development of this process in this country there were not less than 1,000 different special

experimental investigations necessary relating to different problems in the different stages. Mr. Herreshoff used this opportunity to express his appreciation to those who had ably assisted him. Without this assistance and without the assistance which comes from a large corporation it would have been very difficult to carry the research to a successful end.

The great advantage which large corporations have is that they can have large laboratories with highly skilled men. Much has been done in this line in Germany, while in this country we must develop to a greater extent this side of our chemical works. We need larger and better research laboratories. Mr. Herreshoff concluded his remarks by expressing the hope that the Perkin medal would act as a stimulus to further progress.

Concluding Remarks.

Dr. WILLIAM H. NICHOLS, president of the General Chemical Co., then made some "concluding remarks," which contained many characteristic and delightfully humorous touches. He said that it was a peculiar pleasure to him personally to be present to-night, since this presentation of the Perkin medal to Mr. Herreshoff was an example and a proof of his (Dr. Nichols') own ability—and that always gave satisfaction. Thirty-five or thirty-six years ago Mr. Herreshoff was sophomore student in Brown University, and as such he was made teacher to the seniors. As Mr. Herreshoff says now, that was the reason why he never graduated from Brown University.

Dr. Nichols then told how in the beginning of his own connection with the chemical industries he had also looked after the scientific end of the work, but then he lost his partner, who had looked more after the business end. Then Mr. Herreshoff came and wanted to be the superintendent. This was in 1875, and Mr. Herreshoff then took over the scientific end of the corporation, while Dr. Nichols became strictly the business man, and that is, said Dr. Nichols, probably the reason "why I do not get the Perkin medal myself to-night."

Dr. Nichols said that his association with Mr. Herreshoff for these many years had been one of the greatest pleasures of his life. He also read a cablegram from London, in which "Lady Perkin and family cordially congratulated Mr. Herreshoff on the reward."

To learn a great lesson we have to consider what encouragement will give the Perkin medal to the rest of us for our work. It is given to somebody who has done something great for the world of chemistry. For this, as Dr. Nichols explained, three characteristic traits are essential for success, and all three are peculiarly embodied in Mr. Herreshoff: first, simplicity of character, without the slightest trace of duplicity; second, modesty; and third, "when you are at work do not think of yourself, but of the result, then the end will be crowned by success."

After the conclusion of the official meeting of the Society of Chemical Industry a session of the Verein Deutscher Chemiker was held in the well-known enjoyable, informal way. Songs and informal speeches held the meeting together until after midnight. Dr. Schweitzer presided.

New York Section American Electrochemical Society.

At a meeting of the New York section of the American Electrochemical Society, held in the Chemists' Club on December 17, Prof. C. F. TUCKER being chairman, an interesting sketch of the development of modern electrolytic copper refining was given by Mr. Lawrence ADDICKS, of the United States Metals Refining Co. (De Lamar Refinery).

The second paper of the evening was presented by Mr. H. MARTIN on storage batteries. The speaker gave a review of recent developments in storage battery design and illustrated his remarks by a series of lantern slides.

Commercial Methods of Manufacturing Pure Hydrogen.

At the last "Versammlung Deutscher Naturforscher und Aerzte," held in Dresden last autumn, Prof. Dr. Adolph FRANK, of Charlottenburg, discussed different methods for manufacturing pure hydrogen and described a new one in which the starting material is water gas.

Pure hydrogen is at present used chiefly as a filling for balloons and for welding purposes. Its suitability as a gas for filling balloons is indicated by the following figures: 1 cubic meter of air weighs about 1,300 grams; 1 cubic meter of illuminating gas weighs 600 grams, and 1 cubic meter of commercially pure hydrogen gas weighs 100 grams.

Concerning the use of hydrogen gas for autogenous welding, Professor Frank pointed out to what extent the application of the oxy-hydrogen flame has grown in recent years, especially in Europe. Autogenous welding of lead with lead by means of an air-hydrogen flame has been in use for a long time. But when pure oxygen became commercially available at a reasonable price, the higher temperature which is obtained with the oxy-hydrogen flame permits in an analogous way the autogenous welding of iron with iron. This method is especially useful for welding iron sheets up to 15 mm. thickness and small pieces of machinery.

If the welding shall be successful, it is of great importance that there is a certain excess of hydrogen in the flame so that no oxide can form, which would spoil the weld. Professor Frank seems to think that other disturbing effects may result under certain circumstances with the oxygen-acetylene flame. The temperature of this flame is considerably higher than that of the oxy-hydrogen flame, but if the process is not carefully carried out there is a possibility that some acetylene gas, which is present in excess in the flame, dissociates at the high temperature in the process with deposition of carbon. The carbon is eagerly absorbed by the surface of the melting iron, and in this way the structure of the iron at the point of welding may be considerably changed. For this reason some people prefer to use the oxy-hydrogen flame, especially for the autogenous welding of thinner iron plates up to 12 mm. thickness, although the theoretical superiority of the acetylene-oxygen flame cannot be denied.

As to the commercial methods for producing pure hydrogen gas, one of the oldest methods is based on the action of acids on metals (iron or zinc), and is still largely used.

In the Russo-Japanese war the action of alkalies on certain metals was made use of in an analogous way. The Russians employed aluminium, but recently metallic silicon has also been proposed for the same purpose.

Further, there is the production of hydrogen by electrolysis, either as the cathodic by-product of other electrolytic processes, or the intentional production of oxygen and hydrogen gases by electrolysis of water.

Finally, calcium hydride CaH_2 produces hydrogen by simple contact with water.¹

Prof. A. Frank, together with Dr. N. CARO and Dr. A. R. FRANK, has undertaken to produce hydrogen from so-called water gas, which is obtained in the well-known way by passing steam over incandescent coal. While this gas mixture consists theoretically of 50 per cent by volume of hydrogen and 50 per cent of carbon monoxide, the water gas produced in actual producers contains other impurities. The gas generated in some well-known producers consist, for instance, of 50 per cent hydrogen, 40 per cent carbon monoxide, 5 per cent carbon dioxide, 4.5 per cent nitrogen and 0.5 per cent oxygen.

Frank and his co-workers had used such water gas as a source of carbon monoxide in order to produce graphite, by

¹ A similar compound, called "hydron" by the Roessler & Hasslacher Chemical Co., who manufacture it, acts in an analogous way; it is a lead-sodium alloy. A very old method of making hydrogen gas commercially, in use in this country, is by decomposing steam by contact with red-hot iron.

the action of the latter on calcium carbide (concerning this reaction, see our Vol. I., p. 423). They also hoped to make artificial diamonds in this way, but state that they have not yet been successful. They made, however, the observation that after water gas had been passed over heated carbide, the escaping gas was pure hydrogen. This is simply explained by the fact that heated carbide not only reacts eagerly with carbon monoxide, carbon dioxide and oxygen, but also with nitrogen, the latter being bound as calcium cyanamide.

The manufacture of graphite from carbon would, however, be economical only with relatively low prices for carbide, and under present conditions it was evident that in such cases where the chief object is to produce hydrogen, it should be tried to reduce the carbide to a minimum. For this purpose carbon monoxide and carbon dioxide were to be removed from the raw water gas according to well-known older methods by passing the gas over other absorbing agents.

Fritsch and Beaufils had already tried, in the eighties, to make hydrogen gas from water gas by passing the latter through a washing tower filled with cuprous chloride solution. Their final product contained about 80 per cent hydrogen, which would not be suitable either for balloon filling or for welding.

Frank and Jacobi recently modified the process by absorbing the carbon dioxide by means of a lime tower and obtained a purified water gas containing about 80 per cent hydrogen, from which only the rests of carbon monoxide, nitrogen and oxygen were to be removed by passing the gas through a retort filled with heated carbide powder. In this way they succeeded in obtaining a hydrogen gas 99 to 99.6 per cent pure and containing only small traces of methane and nitrogen.

Although this result was satisfactory, the purification of the raw gas by means of large quantities of cuprous chloride and the subsequent regeneration of the latter by treatment in vacuo had certain disadvantages for operation on a large scale.

A simpler method was finally found by liquefying the water gas in the well-known Linde apparatus for liquefying gases. Liquid carbon monoxide has about the same vaporization point as nitrogen, namely, -196° , while the vaporization point of liquid hydrogen is at -253° , so that the separation in this case must be even easier than that of oxygen and nitrogen. The energy required for liquefying the gas in this case is, according to calculation, so small that the whole energy can be obtained by burning the separated carbon monoxide in a gas engine, which gives an economically and technically interesting cyclic process.

Since laboratory experiments would not give any results useful for the practice, Professor Frank, together with Professor von Linde, has equipped a small, but commercially complete plant, with its own water-gas producer for generating to cubic meters of water gas per hour. The results obtained in this plant are to be published later on. Since, according to present experience, the generation of 2,000 cubic meters of pure hydrogen is sufficient for filling three balloons for military purposes, only a single water-gas producer is required. The other apparatus require only small space and little attendance. Besides coke, a moderate supply of carbide is necessary. For a fortress which is being besieged and which cannot get hydrogen gas from outside, this method appears to have great advantages.

Western Association of Technical Chemists and Metallurgists.—The third general meeting of this association was held in Deadwood, S. D., on Jan. 2, 3 and 4. Among the features of this convention were visits to the cyanide mill of the Mogul Mining Co., at Pluma (using the Moore slimes process), to the Homestake mills, to the Homestake filter-press slimes plant at Deadwood, and to the Golden Reward and Imperial Companies' cyanide plants in lower Deadwood. A number of interesting metallurgical and chemical papers were presented, which we will abstract in a future issue.

The Chinese Iron and Steel Industry.

The remarkable fact that last year 2,500 tons of basic pig iron, and later several lots of foundry and pig iron, were shipped from China to the United States, gives considerable interest to an account of the Chinese iron and steel industry, at present practically concentrated in the Hanyang Iron & Steel Works, which we find in *Stahl und Eisen* of Jan. 1, from the pen of a former engineer of these works, Mr. C. BLAUEL.

The Hanyang Iron & Steel Works are located at the junction of the Han River and the Yangtse River, right near the city of Hankow, which is the greatest and most important commercial center on the immense waterway formed by the



BLAST FURNACE PLANT IN HANYANG (MAY, 1907).

Yangtse River. The distance of the works from sea coast is about 720 miles.

The works were founded in 1891 by the new governor of the province of Hupeh, Chang-Chi-Tung; the plant erected at that time, chiefly under the direction of English engineers, consisted of two blast furnaces, each of 50 tons daily capacity, twenty puddling furnaces, arranged in groups of four, two Bessemer converters, each of 5 tons capacity, one basic 12-ton open-hearth furnace, and two rolling mills, a foundry, etc.

The blast furnaces have been in operation since 1894, but not continually. In the first years only one furnace was generally in operation. By various improvements the daily capacity



STEEL WORKS AND ROLLING MILLS.

per furnace was later on increased to 70 or 100 tons, according to the quality of the pig iron. The puddling furnaces were in operation for only a short period.

The converter plant which received the pig iron, remelted in cupolas, has produced since the end of the nineties chiefly steel for rails of the Hankow-Peking Railroad, which was

built between 1900 and 1905. Besides this, the converter plant and the open-hearth furnace supplied steel to the sheet mills. The yearly output of the rolling mills was hardly more than 15,000 or 20,000 tons and generally much less. In 1896 the works were leased by Governor Chang-Chi-Tung to a Chinese company.

The disadvantages under which the undertaking labored were, in technical respect, inferior coke and, in commercial respect, financial mismanagement by the Chinese managers. At intervals the funds were exhausted, and on one such an occasion, before 1900, the company acting against the advice of its engineers, entered into an agreement with the Japanese government steel works in Wakamatsu, to furnish them for thirty years yearly 100,000 tons of the best magnetic ores, low in phosphorus, at the price of about \$1.50 per ton, f. o. b. shipping docks.

This agreement endangered the whole existence of the Bessemer plant, since most of the other available chief ores contained too much phosphorus (0.1 to 0.25 per cent). A great part of the coke also contained small quantities of phosphorus.

In 1904 the works became almost completely the property

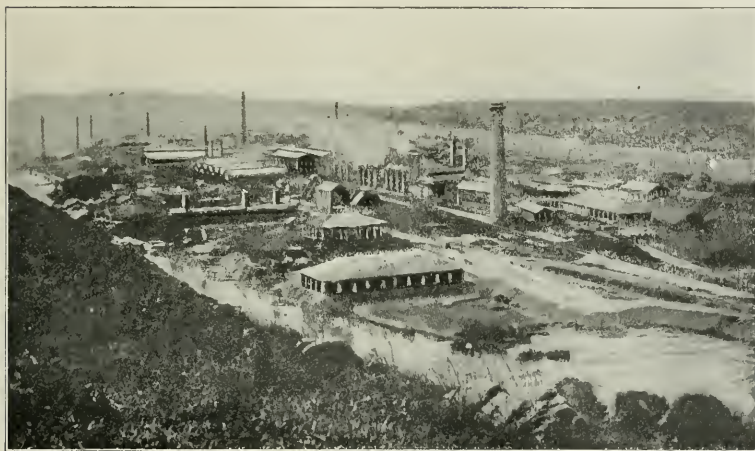
making, at a distance of about 18 to 24 miles from the ore deposits.

The new Chinese mining law which was issued in the beginning of November in Peking, does not permit foreign capital to be employed directly in mining in China. Foreigners are only permitted to become stockholders in Chinese companies. If this law should hold, it will take a long time before the Chinese iron industry will flourish. For in spite of the excellent natural advantages of large, good raw materials and easy shipping facilities, very essential changes in the Chinese methods of accounting will become necessary before the investment of money in Chinese mines will assume a promising aspect to the foreign capitalist.

The ore deposit is connected by a 15-mile railroad of normal gauge, with a shipping station on the Yangtse River, from where the ores are loaded on shipboard and carried to the iron works, a distance of about 72 miles. The ores which are exported to Japan are directly loaded into an ocean liner. The loading and unloading are done by coolies, who get 6 cents for 10 hours' work.

The Yangtse River, which is the main waterway of China, and has already an immense traffic, is navigable for the largest ocean steamers up to Hankow from April to October. At Hankow at mean water level it is still almost about a mile wide.

The coal mines near Ping-Hsiang have now been developed so far that a solid coke with about 12 to 15 per cent of ash and 0.8 per cent sulphur is produced. The production is large enough to operate the blast furnaces in Han-yang exclusively with such coke. The difficulty is the necessity to carry the coke by rail a distance of 60 miles and then by water for more than 240 miles. This takes considerable time.



HANYANG IRON AND STEEL WORKS.

of the railway director, Sheng-Kung-Pao, and in order to make all magnetic and hematite ores available for working, it was decided to erect a new modern open-hearth furnace plant with large rolling mills, and experts were sent to the United States, England and Germany.

The iron ores of the Tayeh district, at a distance of about 60 miles from Hankow, are chiefly red hematite and magnetic iron ore of the following average composition:

58.0 to 68.0 per cent Fe	0.04 to 0.25 per cent P
3.0 to 7.0 per cent SiO_2	0.05 to 0.1 per cent S
1.0 to 2.0 per cent Al_2O_3	0.05 to 0.25 per cent Cu
0.2 to 0.4 per cent Mn	

There is also found brown hematite containing 6 to 9 per cent of manganese. The deposit of the two chief ores is estimated to amount to more than 100,000,000 tons. They occupy a mountain range of about 7 miles in length. On the side where the iron ore is low in phosphorus, the ore is in contact with limestone, which occurs there in immense quantities as almost pure carbonate of calcium. This district will probably be one of the future centers of the Chinese iron industry, since besides the immense deposits of ore and limestone there is also available good coal suitable for coke

The costs of the raw material per ton, free at the blast furnace, were formerly much higher, but have now decreased to the following values: Ore about 75 cents, limestone 50 cents, coke \$6.25 to \$7.50, and Ping-Hsiang coal \$4.50.

After it had been decided to rebuild the whole works and make them up-to-date, three open-hearth furnaces, each of 30 tons, were bought in the years 1904 and 1906 in England and Germany; further, a gas-fired mixer of 150 tons with gas producer, three large reversing mills and accessories. Electric power is used, and for this purpose a direct-current plant of 800 kw. was installed.

In the beginning of 1907 a third blast furnace for 300 tons daily product was ordered and a fourth and fifth open-hearth furnace, while a second mixer shall be installed later on, also a fourth blast furnace for 300 tons daily output. The old Bessemer plant and the puddling furnaces were dismantled.

At present the two old blast furnaces, which produced daily 70 to 100 tons, the old 12-ton open-hearth furnace and the old rolling mill have been in operation since last year, also part of the electric plant. The new steel plant as well as the new rolling mills was recently set in operation, and it is expected that the third blast furnace will be started before the end of 1908.

All the work of erection was done by Chinamen under the direction of European engineers and foremen. Chinese workmen are slow and not careful, but the wages are very low. As mentioned above, the lowest class of workmen, the coolies, get 6 cents for 10 hours' work. Skilled labor gets higher wages. Thus, varying according to experience and age, carpenters and plumbers get \$5 to \$17.50, machinists and workmen making installations from \$4 to \$25 per month (i. e., working twenty-five to twenty-eight times for 10 hours). Foremen at the furnaces, rolling mills and in the workshops get \$10 to \$47.50 per month. In seaports on the Chinese coast the wages are higher.

Mr. Blaul thinks it is difficult to form a definite opinion concerning the future of the Hanyang Iron & Steel Works. It is certain that the prospects for success are now better than ever before, not only on account of the much better equipment of the works and of the greater experience of the workmen but because the raw material problem has now finally been regulated.

The steel works and rolling mill output may be 40,000 to 50,000 tons during 1908, if no unexpected difficulties occur. When the third blast furnace has been started, that is in 1909 or 1910, the yearly production may reach 100,000 tons.

Of great importance for the situation is the fact that the present general manager of the plant is Mr. V. K. Lee, who has been for many years in Europe and Japan, and represents the highest and best type of Chinese. The technical management has been always in the hands of foreign engineers and foremen.

Engineers from England, Belgium, Luxemburg, Germany and France come and go, and in most cases, as at present, the engineering staff is international. However, the long tropical summer of the Middle Yangtse Valley renders it difficult for most foreigners to stay for any length of time.

In summer the temperature of the air is for weeks, day and night, above 30° C., rising up to 40° (87 to 104° F.). In July and August even the Chinese find the climate too hot for work, so that in Hanyang it was the custom in the past to stop operation of the steel works and rolling mills for several weeks. With the new improved equipment and better ventilated halls it is hoped that this stopping may be avoided.

The output of the blast furnaces—which in the years 1905 to 1907 was chiefly pig iron for foundry use and steel making and high percentage spiegeleisen—was partly consumed at the plant itself or sold to Japan or to Chinese seaports.

Although the region of the middle and upper Yangtse River has not yet been fully explored with respect to its mineral deposits, yet as far as the results of investigations show there are not only rich metal deposits (gold, silver, copper, zinc, lead, antimony) but also large deposits of coal and iron ores.

Rich iron ore deposits have been definitely located in the provinces of Kweichow and Kiangsu. Brown hematite containing some 20 per cent manganese is found in large quantities at the Poyang Sea, about 150 miles from Hankow. If the rich iron ore deposits in Shantung, Hunan, Kuangtung, Kuangsi are taken into consideration and those in Tongking, which now belongs to France, Mr. Blaul thinks that the quantities of iron ore available in China are not much less than those in the United States. While coal for coke making is not available in equal abundance yet there are rich deposits. Most promising for the development of the Chinese iron industry is the district of the Yangtse River, especially on account of the excellent waterway to the coast.

Besides the Hanyang Iron & Steel Works, the Chinese government arsenals, which make chiefly rather inferior guns and cannon, erected open-hearth and crucible furnace plants with rolling mills in Shanghai, Hanyang, Fouchow and Tientsin. Not only did the erection of these works consume a very long time but the operation was stopped after longer or shorter periods, since the experience was always that the

best financial balance sheet at the end of the year was obtained when the works did not work.

Some private iron foundries and factories for machinery are found in the larger seaports of China, often in connection with shipbuilding and repair docks. The more important ones are in European hands. During the last years they have had much work on hand but have used exclusively European iron. The wages at these places are very much higher.

Mr. Blaul finally mentions an attempt made in the beginning of the nineties to develop an iron industry in the province of Kweichow. A small blast furnace with accessories, bought in England, was to be set in operation by Chinese who had studied blast-furnace working for several months in an English plant. They believed they could do the work without the help of foreign engineers, and were, therefore, greatly disappointed when right at starting the furnace the charge froze. Since that time, the furnace, filled with its charge, has been left alone and stands as an interesting document of the abhorrence the Chinese have against foreigners and their art.

While the success of Japan in the last years has undoubtedly had an inspiring influence on China, the internal political situation in China is immensely more difficult and its development will have a great influence on the evolution of industries in China. If industries develop, it may be expected that, as in Japan, this will occur with the use of foreign capital but by Chinese educated in Europe, America and Japan, while the endeavor will be to keep foreigners as much as possible away from the works.

Electrochemical Analysis with Rotating Anodes in the Industrial Laboratory.

II.

By ANDREW M. FAIRLIE AND ALBERT J. BONE.
METHODS OF ANALYSIS.

In applying the principle of stirring the solution during electrolysis to the estimation of copper in comparatively pure material (such as converter bars), no change in the chemical treatment of the sample from the usual procedure for stationary electrolysis is necessary. Even with impure products, according to our experience, there is only one class of samples—namely, those in which a small percentage of copper is associated with a preponderant amount of iron—requiring any modification of the usual analytical scheme. The deviation from the usual chemical treatment in the analysis of such highly ferrous samples, though apparently slight and of little moment, is the *sine qua non* for the attainment of uniform and reliable results. What this modification is will appear below.

As hinted in the preceding paragraph, the application of rotating anodes to the analysis of such materials as copper matte and blister copper presented no difficulties, when the apparatus described in the first part of this article¹ was first tried. But it was desired to apply rotating anodes also to the estimation of copper in the daily slag samples. The high percentage of iron in the slags, however (40 to 50 per cent FeO), at first proved an obstacle to permanent deposition. Frequently the copper refused to deposit at all, even after passing a current of 3 amps. for 20 or 30 minutes. At other times, when the deposit did appear with reasonable promptness, it dissolved again, leaving the cathode absolutely bare. Experiments were instituted to investigate the difficulty.

The weight of slag taken as a basis for experimenting was 3 grams. Many different trials were made, varying the amounts of nitric acid and sulphuric acid in the electrolyte. These experiments it is unnecessary here to recount. In most cases, with 2 c.c. or more of nitric acid present in 150 c.c. of solution, the copper, after depositing, redissolved, the following phenomena being, as a rule, observed: About 5 minutes after turning on the current the color of the solution

¹ This journal, January, 1908.

began to darken, and simultaneously a deposit of copper was noted on the cathode. As the current continued to pass the solution became darker and darker, until just about the time the deposition of copper was complete the dark color vanished, and as suddenly the deposited copper redissolved in the electrolyte, which at this juncture gave only a slight test for ferrous iron.

Our experiments have led to the conclusion that the darkening of the solution (which sometimes occurs to a less marked extent even in stationary solutions electrolyzed with a low current) is due to the reduction of iron by the hydrogen liberated by electrolytic action, and to the consequent "browning" reaction with nitric acid. This reduction of iron facilitates the deposition of copper, ferrous sulphate, unlike ferric sulphate, possessing little or no solvent tendency. The continued darkening of the solution is an indication of the gradually increasing quantity of ferrous iron and then of the "brown-ring" compound. The decomposition of this compound [$(\text{FeSO}_4)_2\text{NO}$], indicated by the sudden disappearance of the brown color, results in the oxidation of the iron to ferric sulphate, which in turn dissolves the copper on the cathode.

Experiments were made with solutions free from nitric acid—some containing sulphuric acid only, and others sulphuric acid and phosphoric acid; but deposition was slow and the deposits were unsatisfactory. It has been found, however, that by reducing the amount of nitric acid to 1 c.c. for 150 c.c. of electrolyte the copper deposits promptly and also survives the reoxidation of the iron. The same darkening of the solution occurs as when two or more c.c. of nitric acid are present, but with only 1 c.c. the copper does not redissolve when the brown color vanishes. The reason, we conclude, is that with only 1 c.c. HNO_3 in 150 c.c. of electrolyte, less iron is reoxidized, and the concentration of the ferric sulphate is too low to exert solvent action in the presence of the electric current.

If more than 1 c.c. of nitric acid be used, or if more than 3 grams of our slag be taken for a sample, thus increasing the weight of iron in the electrolyte, the bulk of the solution must also be increased to obtain satisfactory results; but this necessitates a longer time for the complete deposition of the copper.

The foregoing observations lead to the belief that in submitting a copper solution to electrolysis, it is necessary to adjust the degree of concentration of certain solvents of copper well within fixed limits, beyond which not only will deposition be greatly retarded, but the copper, once deposited, may even be redissolved, in spite of the continuous passage of the electric current. The solvents most likely to be encountered in industrial practice are ferric sulphate and nitric acid. To determine the solubility of deposited copper, during the passage of the electric current, in these two solvents, cathodes were plated with copper, and were then subjected, while the current persisted, to the action of solutions containing a known amount of iron or nitric acid for a given period, at the end of which the solvents were removed and tested for copper with H_2S water. In making the experiments the following conditions were constant:

Copper deposited on cathode.....	10 mg.
Volume of solution.....	150 c.c.
Temperature of solution.....	52° C.
Duration of test.....	2 minutes.

The quantities required to exert a solvent action are given below:

ANODES.	AMPERES.	PRESENT IN SOLUTION.	
		Mg. Iron as Ferric Sulphate.	Per cent. by Volume of Nitric Acid (1.42 sp. gr.).
Rotary.....	3.0	703	None
Rotary.....	3.0	None	21.3
Stationary.....	0.3	610	None
Stationary.....	0.3	None	9.0

Ferrous sulphate is practically without solvent power under the above conditions. Copper deposits were submitted to the action of both rotated and stationary solutions containing as much as 5 grams of metallic iron, as ferrous sulphate, but no action was perceptible.

Lack of spare time has prevented an exhaustive inquiry into all of the mysteries attending the re-solution, in the presence of the electric current, of copper once deposited. The subject is one worthy of careful study by some investigator in a laboratory of pure science, who has the means and the time to delve to the bottom. For ourselves, we must be content with the attainment of our object—the discovery of a practical and reliable method of assaying copper slags with rotating anodes.

Numerous experiments made in this laboratory show that insoluble matter, even as much as 2 grams, suspended in the stirred electrolyte, will not cause low results; but it might lead to high ones, as globules and flakes of sulphur, resulting from the decomposition of sulphide ores, have a tendency to cling to the perforations of the cathode. So far as the weight of the deposited copper is concerned it is entirely permissible to rotate slag solutions without removing the silica, but an objection to such a practice is that the silica somewhat masks the H_2S test for copper.

In electrolyzing copper solutions by means of our octuple rotating apparatus, the following manipulation is involved:

The electrodes are placed securely in position, the anode being inside the cathode. The beakers containing the solutions to be electrolyzed are raised, thus immersing the electrodes, and are supported by wooden blocks. They are then covered with strips of glass provided with suitable apertures for the stems of the electrodes. The motor is started and the current turned on. When the bulk of the copper is deposited the covers are washed off, likewise the sides of the beakers and stems of the electrodes. Electrolysis continues until such a time as experience shows is necessary for complete deposition, but before the cathodes are removed about 1 c.c. is abstracted from each beaker and tested for copper in a porcelain dish with strong H_2S water. As long as any color with H_2S is perceptible, electrolysis is continued. To render this test more delicate in solutions containing much iron, a drop of phosphoric acid may be added to the portion of the solution to be tested, the color caused by the iron thereby being destroyed.

When all of the copper is deposited the motor is stopped, the switch controlling the first pair of electrodes turned, the beaker containing the electrolyte lowered and another containing distilled water quickly substituted. Into this the cathode is allowed to drop, beaker and cathode are removed from the electrolytic rack, and the motor is started to continue stirring the solutions not yet removed. The released cathode is washed in water, three times in alcohol, ignited and placed on a tray. The remaining cathodes are treated in the same way, one after another, but fresh water is provided for the removal of each cathode. It is not advisable to remove a cathode without first stopping the motor, as an appreciable amount of copper is soluble in distilled water when rapidly stirred (if no current is passing), this solvent tendency being greatly enhanced by the small amount of acid solution which adheres to the electrodes when the original beaker is removed. Without stirring, some copper will dissolve in the slightly acid solution, and to a less marked degree in water practically pure, and even in absolute alcohol; such loss, however, is very small and usually negligible. When extreme accuracy is desired the acid solution should be siphoned off and gradually replaced by distilled water before the current is interrupted.

PROCEDURE.

Converter Bars.—Dissolve 5 grams in a 250 c.c. beaker. Griffin shape, with 21 c.c. nitric acid (sp. gr. 1.42), and add 5 c.c. sulphuric acid (sp. gr. 1.84) and evaporate to dryness.

Take 500 cc with 75 c.c. water and 2.5 c.c. nitric acid, and boil to dissolve all copper salts. Dilute with water to 150 c.c., and electrolyze with the following conditions prevailing: initial temperature, 50-55° C.; N. D.₁₀₀ = 5 amps.; time 2 hours; r. p. m. of anodes, 400-500.

Mattes.—Treat 1 gram in a 250 c.c. beaker with 15 c.c. of a mixture of nitric acid and bromine (prepared by shaking 10 c.c. of bromine with half a liter of nitric acid), and allow to stand a few minutes in the cold until the sulphur is oxidized, adding a few drops of bromine if necessary. Add 4 c.c. hydrochloric acid, boil gently to complete decomposition, and evaporate to fumes with 2 c.c. sulphuric acid. Cool, take up with 50 c.c. water, 2 c.c. sulphuric acid and 2 c.c. nitric acid. Boil to dissolve all soluble salts, dilute to 150 c.c. and electrolyze. Initial temperature, 50-55° C.; N. D.₁₀₀ = 3 amps.; time, 45-55 minutes; r. p. m. of anodes, 400-500.

Ores.—Take 1 gram and heat gently with 10 c.c. nitric acid until all red fumes are expelled, then evaporate to dryness with 1 c.c. sulphuric acid. Cool, take up with 50 c.c. water, add 3 c.c. sulphuric acid and 2 c.c. nitric acid, boil, and filter into a 250-c.c. beaker. Dilute the filtrate to 150 c.c., and electrolyze. Initial temperature, 50-55° C.; N. D.₁₀₀ = 2 amps.; time, 40-50 minutes; r. p. m. of anodes, 400-500.

Slags.—Treat 3 grams in a 4-inch casserole with 15 c.c. hydrochloric acid, stir well, add 5 c.c. nitric acid, stir again, cover, and boil for 5 minutes. Remove from heat, slip back the cover a trifle, and add 4 c.c. sulphuric acid. When the violent action has ceased, wash the cover and sides of the casserole, stir the mass well, and evaporate to dense white fumes. Cool, take up with 30 c.c. cold water, add 1 c.c. nitric acid (accurately measured from a burette), boil well, filter, using suction, and wash thoroughly. Transfer the filtrate to a 250-c.c. beaker, dilute, if necessary, to 150 c.c., and electrolyze. Initial temperature, 50-55° C.; N. D.₁₀₀ = 3 amps.; time, 35-40 minutes; r. p. m. of anodes, 400-500.

The methods outlined above are applied to copper determinations in ores and products remarkably free from interfering elements. Where the latter are present in appreciable amounts certain modifications must be resorted to.

Rotating anodes have been in daily use in the laboratory of the Tennessee Copper Co. for the past eight months. To ascertain the comparative accuracy of the method for slags, check assays were made every day for a period of four months on samples of the two types of blast furnace slags, designated respectively "green ore" and "concentration" slags. The check assays were made on five-gram samples in the following manner: The sample was treated with acids as described above for slags, but instead of adding nitric acid to the filtrate from the silicious residue and electrolyzing it, the copper was precipitated by aluminium and H₂S water, and was then dissolved in nitric acid and electrolyzed overnight in a stationary solution with a low current. The average results for the four months follow:

TYPE OF SLAG.	PER CENT. Cu.	
	3 grams Rotated.	5 grams, Stationary.
"Green Ore" ..	0.270	0.279
"Concentration" ..	0.648	0.649

Our experience with rotating anodes is limited to copper determinations, and for this work they have certainly fulfilled our expectations. It seems reasonable to assume that other metals, zinc and lead, for instance, may be rapidly estimated on a practical scale by electrolyzing stirred solutions.

COPPERHILL, TENN.

Metallic Value of Ores.—A little table, recently issued by the Traylor Engineering Co., of New York City, is very useful, giving a list of the most important ores with percentage of metal contained and specific gravity.

Calculations for Power Plants.

By DR. FRANZ H. HIRSCHLAND.

Every manufacturer of chemical, mechanical or any other goods has to make himself familiar with the kind of power and power generation which he wants to use in his factory. The success of an enterprise depends, to a great extent, on the price of power. The decision on the location of a plant is not merely influenced by railway connections, source of raw materials, points where to deliver the goods, labor questions, etc., but also to a great extent by the power question. Especially important, of course, is this question in electrochemical enterprises where power is the greatest expense.

To solve the question which kind of power and which kind of power generation is the best and most advantageous one, in a general way, is an impossible task. The items, which have to be considered on answering such a question, change from case to case, and depend not only on the size of the power house, the number of hours which the machines have to run, but also on the voltage which may be required and many other points.

To give a scheme how the power generation question can be solved from case to case, one example is taken in the following and a comparison is set between.

1. Steam.
2. Gas.
3. Hydro-electric power.

It is presumed that a power house of 800 kw., delivering 6,200,000 kw-hours per year, is used for an electrochemical process. The plant having to run about 24 hours per day makes it necessary to devote special consideration to the spare engines.

To give a comparison between the different kinds of power generation, the utility of a plant in a general way, the price of the plant and the price of the current at the switchboard have to be compared.

I. STEAM POWER.

On deciding on a steam power plant there is the choice of either steam engines or turbines. With regard to the expenses of the plant and economy of the same, both plants are about equally good, but it has to be considered that the high speed of the turbines combined with the low voltage of the dynamo machines required for electrolytical purposes, makes the use of the turbine less advantageous.

Should steam also be required for heating and melting purposes, as it is often the case in electrolytical processes, this can be easier done from a steam engine than from a turbine. With steam engines it is possible to take steam either out of the receiver between high and low-pressure cylinder, or to let one of the steam engines run without condenser, the same working with a certain counter pressure. With steam turbines the same solution would materially affect the economy of the plant.

There being no great difference in price, space and equipment between steam engines and turbines of the required size, the choice remains more a matter of personal taste than of technical advantages.

A condensing plant can be considered in most cases to be economical, at least if a factory site can be located in such a way that there is a sufficient amount of cooling water.

The use of superheated steam for the steam engines would scarcely bring any advantages, as the valves of the Corliss engines, which are most extensively used in this country, would have a tendency to bind. With turbines, on the other hand, the use of superheated steam would have to be very seriously considered.

For both cases a steam pressure of 150 pounds and a vacuum of 26 inches would meet the local requirements.

Assuming the above-mentioned points, the *price of an electrical power station* of 800 kw., driven by a steam plant, would be, approximately, as follows:

Factory site.....	\$.....
Building with stack.....	28,000
Steam generators.....	20,000
Foundation	2,000
D. C. dynamos with switchboard, complete....	24,000
Steam boilers, including brickwork, complete.	16,000
Condenser, complete.....	2,000
Pumps, feed-water heater.....	2,500
Piping, complete.....	6,000
Traveling crane.....	6,000
Freight (?).....	2,000
Erection of all machinery.....	6,000
Total cost of installation.....	\$114,500

The consumption of steam for a plant would be about 14 pounds per 1 hp-hour, or about 25 pounds per kilowatt-hour at the switchboard, in which latter amount the consumption of the auxiliaries is included. With an evaporation of 8 pounds of steam with 1 pound of coal of 13,000 to 14,000 B. T. U., 1 kw-hour can be generated with 3 pounds of coal.

The *price of current at the switchboard* is composed as follows:

1. Depreciation and interest—

According to local usage the depreciation and interest, including repairs and insurance, can be put at 14 per cent of the capital amount, which makes per year..... \$16,000

2. The operating expenses are divided into—

A—Labor.

One would require, assuming two shifts, ten men earning per year about..... 7,430

B—Fuel.

For the generating of 6,200,000 kw-hours, at 3 pounds of coal per kilowatt-hour, 9,300 net tons of coal will be required per year. The different kinds of coal, which can be used for steam boilers, vary greatly in price according to the distance from the mine. Near the mines themselves this coal can be obtained for about \$1.25 per ton. Using this lowest figure to calculate on, the coal price would bring up the expenses for this item per year to..... 11,600

C—Petty Expenses.

Lubricating oil being the principal factor, this expense can be put down at a yearly figure of about..... 4,000

Drawing all these different expenses together, one finds that with a price of \$1.25 per ton for coal the expenses for the generating of 6,200,000 kw-hours during the year are, approximately..... \$39,000

The price for 1 kw-year is therefore \$55.20.

II. GAS POWER.

The gas engine has in the last few years awakened great interest all over the world.

First-class machine factories have begun the building of these engines, and many special factories already exist which make nothing but producers.

A large field has also been opened for the combustion engine on account of the large available supplies of natural gas. The oil engine is also extensively used for certain purposes.

A—Producer Gas Plant.

Producer gas plants are made both for anthracite and bituminous coal. For soft coal the plants become more difficult to serve and the cleaning of the same is awkward. The price for such a plant is also several thousand dollars higher than for the same with anthracite. The safety factor and economy is in both plants roughly the same. The choice of one or the other can only depend upon the price of coal. Where both sorts of coal are equal in price there could be no hesitation in choosing anthracite.

All firms guarantee 80 per cent efficiency for their producers; that means they can obtain from 1 pound of coal of 13,500 B. T. U. an amount of gas with 10,500 B. T. U. The caloric value of producer gas ranges between 125 and 150 B. T. U. per cubic foot.

The *cost of an electrical power station* of 800 kw., with a producer plant using anthracite coal, would then be as follows:

Factory site.....	\$.....
Building	23,000
Gas engines.....	55,500
Foundation	7,500
D. C. dynamos with switchboard, complete....	24,000
Gas producers.....	21,000
Foundation	6,000
Compressed air starting apparatus.....	2,000
Water pumps with electric motor.....	1,000
Piping, complete.....	4,500
Traveling crane.....	6,000
Freight (?).....	2,000
Erection of all machinery.....	7,500
Total cost of installation.....	\$160,000

The price of a similar plant for soft coal would be about \$165,000, the higher price being explained by the more expensive producer.

The consumption of coal in a producer plant shows the same to be very economical. The gas engine generates with about 10,500 B. T. U.—one braked horsepower-hour. With an efficiency of the producers of 80 per cent and coal of 13,500 B. T. U., one comes to the result that 1 pound of coal produces one braked horsepower-hour.

One pound per braked horsepower-hour is the claim which all gas engine manufacturers bring against their competitors in the steam engine branch, meaning thereby either a good, soft coal, the size of which is not especially important (as the same binds, anyhow), or an anthracite coal of at least No. 1 buckwheat size; that means a coal which is sieved through netting 9/16 inch diameter. One can safely reckon upon the consumption of 1.9 pounds per kilowatt-hour at the switchboard, including all losses and the auxiliaries.

The *price of current at the switchboard* would be as follows:

1. Depreciation and interest—

14 per cent of \$160,000..... \$22,400

2. Operating expenses—

A—Labor.

Ten men..... 7,400

B—Fuel.

1.9 pounds per kilowatt-hour, therefore, for 6,200,000 kw-hours, 5,900 tons, at the price of \$1.25..... 7,400

C—Petty Expenses.

(More and better quality of lubricating oil used than with steam engine)..... 5,000

With coal at \$1.25 per ton the entire expenses for generating 6,200,000 kw-hours per year come to..... \$42,200

The price of 1 kw-year is therefore \$59.60.

The depreciation and interest on gas engines being higher than on steam engines, the consumption of fuel on the other hand, higher with steam engines, gives one a certain coal price at which the generating expenses of both plants are equal.

In the above-mentioned cases this would be at a coal price of \$2.18 per ton. If the price of coal is cheaper than this figure the steam engine plant is more economical; with higher prices of coal the gas engine plant is cheaper.

When having to pay a price of \$3.00 per ton for coal, as, for instance, in New York and Jersey City, the price of current for a gas engine plant would be about \$67.20 per kw-year, and for the steam engine about \$73.00 per kw-year.

In regard to safety and simplicity of regulation, both plants would be about equally good. The fact that one can over-load a steam engine very much more than a gas engine, is not so important in an electrolytic plant on account of the current consumption being particularly constant.

B—NATURAL GAS PLANT.

Natural gas, which is especially well suited for gas engines, is to be had in the States of Pennsylvania and West Virginia. It has a very high caloric value, which can be placed at about 1,000 B. T. U. per cubic foot.

The price of such a plant would be, approximately, as follows:

Factory site.....	\$.....
Building	9,000
Gas engines.....	52,000
Foundation	7,000
D. C. dynamos with switchboard, complete.....	24,000
Compressed air starting apparatus.....	2,000
Water pump with electric motor.....	1,000
Piping, complete.....	6,000
Traveling crane.....	6,000
Freight (?).....	1,500
Erection of all machinery.....	7,000

Total cost of installation..... \$115,500

The consumption of natural gas in a gas engine which can generate 1 hp-hour out of 10,500 B. T. U. would be 10.5 cubic feet per braked horsepower-hour, calculating upon 1,000 B. T. U. per cubic foot. With all losses and reckoning the auxiliaries the consumption would then be about 18 cubic feet per kilowatt-hour at the switchboard.

The price of the current at the switchboard would then be as follows:

1. Depreciation and interest—	
14 per cent at \$115,500.....	\$16,200
2. Operating expenses—	

A—Labor.

Six men.....	4,700
--------------	-------

B—Fuel.

The consumption for 6,200,000 kw-hours at 18 cubic feet per kilowatt-hour is equal to 112,000,000 cubic feet per year. The price varies in the different cities from 4 cents to 20 cents per 1,000 cubic feet. Assuming a price of 4 cents per 1,000 cubic feet, the expense for fuel would be per year..... 4,480

C—Petty Expenses.

(Lubricating oil, etc.).....	5,000
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Total expense, therefore, for the generating of 6,200,000 kw-hours per year with natural gas, at a price of 4 cents per 1,000 cubic feet, would then be.... \$30,380
The price of 1 kw-year is \$42.90.

This price is comparatively low. The engine can also be considered as perfectly reliable. The only question is whether

the flow of gas can be entirely relied upon or not. The difficulties which arise therefrom can be partially overcome by placing the plant as near to the natural gas well as possible, as the flow of gas is mostly disturbed through breakage and repairing of the gas pipes. In many parts of West Virginia the gas wells are considered to be inexhaustible, and especially so in Clarksburg and Fairmont, where gas at a price of 4 cents per 1,000 cubic feet can be obtained, and which cities are situated in the midst of great bituminous coal mines. At all events, it is advisable to consider the possibility of a failure, or at least a reduction of the pressure in the supply of natural gas, and it should be stated at this point that the alteration of a plant for natural gas into a producer plant is, under all circumstances, feasible.

Producer gas having a much smaller caloric value than natural gas, will make it necessary, in converting one plant into the other, to make certain alterations in the engines. The simplest method would be to alter either the mixing valves for gas and air or the compression. In this case the output of the machines would be reduced by about 20 per cent on account of the low caloric value of the gases. The dynamo machines would also be not used to their full load, and one would therefore require a new unit in order to attain the same current as formerly.

For this reason many firms recommend the use of new cylinders, retaining the frame, fly-wheel and all other parts, though some manufacturers think that the same effect could be reached by reboring the cylinder to 1 inch more in diameter and using new pistons.

C—OIL PLANT.

For small plants, or in places where there is little room available, the oil engines can be used with advantage, especially as one saves the space necessary for a producer or boiler. Up to now, engines have not been built for more than a 150-kw., so that for this special case one would require 7 units, counting in two spare engines.

The price of such a plant would be approximately as follows:

Factory site.....	\$.....
Building	14,000
Seven oil engines.....	104,300
Foundation	8,000
Seven D. C. dynamos with switchboard, complete.....	28,350
Compressed air starting apparatus.....	2,000
Water pumps with electric motor.....	1,000
Piping, complete.....	5,350
Traveling crane.....	6,000
Freight (?).....	2,000
Erection of all machinery.....	10,000

Total cost of installation..... \$181,000

The oil consumption would be 1 pound per braked horsepower-hour, which comes to about 1.6 pounds per kilowatt-hour at the switchboard, all losses and auxiliary machinery included.

The price of the current at the switchboard would then be as follows:

1. Depreciation and interest—	
14 per cent of \$181,000.....	\$25,300
2. Operating expenses—	

A—Labor.

Six men.....	4,700
--------------	-------

B—Fuel.

The consumption of 1.6 pounds, or 0.21 gallon per kilowatt-hour would be for 6,200,000 kw-hours per year, 1,300,000 gallons, costing with the price of oil at 2 cents per gallon..... 26,000

C—Petty Expenses.

(Lubricating oil.)..... 5.000

The total expenses for 6,200,000 kw-hours per year with an oil-engine plant would be, with oil at 2 cents per gallon, about..... \$61,000

The price per 1 kw-year would therefore be \$86.00.

This price per kilowatt-year, calculating upon an oil price near the points of production, is so high that the use of the oil engine cannot be considered in this problem, especially as the price of the oil in the East is double that quoted.

III. HYDROELECTRIC POWER.

Though the direct use of turbines and water power is uneconomical in very small plants, the same becomes a most important factor if it is worked on a large scale, as, for instance, at Niagara Falls. In the big turbine plants very high voltage alternating current is generated, which is especially adaptable to the transmission of energy.

For our purpose it would therefore be necessary to transform the alternating current into a direct current of 150 to 200 volts. A rotary converter would be the simplest method of solving this problem, but in consideration of the great difference in voltage on both sides of the machine it will be better in this case to use a motor generator. This plant shall consist of 2 units, as a spare unit may not be needed in such a simple plant.

The approximate price of such a plant would then be as follows:

Factory site.....	\$.....
Building	7,000
Motor generators with switchboard, complete.....	30,000
Foundation	1,400
Freight (?).....	400
Erection of all machinery.....	2,000

Total cost of installation..... \$40,800

The efficiency of the plant could be taken at about 0.87. The price of the current at the switchboard would then be as follows:

1. Depreciation and interest—
14 per cent of \$40,800..... \$5,700

2. Operating expenses—

A—Labor.

Two men..... 1,600

B—Current Consumption.

The lowest price of 1 hp-year, which may be offered at the present time, is \$16.00; 6,200,000 kw. per year, or 1,100 hp-year, will represent..... 17,600

C—Petty Expenses.

(Lubricating oil, etc.)..... 1,000

Total expense, therefore, for a plant of 6,200,000 kw-hours per year, at a price of \$16.00 per horsepower-year, would then be..... \$25,900

The price for 1 kw-year would, therefore, be \$36.60.

This is the lowest price for electric current which we can obtain. An electrical power plant containing a motor-generator can be considered as the most reliable method of generating current for continual service. The cleanliness and easy control of the power plant are an advantage, and the small yearly expense for repairs and renewals is well known. The cost of installing such a plant is considerably lower than that of any other, and the small amount of space required is remarkable.

Metallurgical Calculations.

By J. W. RICHARDS.

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The Metallurgy of Lead.—II.

The principal operations in the metallurgy of lead are the roasting of the ore, its reduction to metal and the refining of the crude metal.

Roasting of Lead Ores.

The chief ore of lead being galena, PbS, the operation of roasting it in air converts it partly into PbO and partly into PbSO⁴. Since PbS is easily fusible, and is volatile *per se* at a yellow heat, it is necessary to roast carefully and slowly, avoiding high temperatures, which first make the ore sticky or pasty and afterwards fuse it, thus practically stopping the roasting reaction. The only manner in which rapid roasting can be done is by having the ore mixed with so much infusible inert matter, like lime, that the globules of melted sulphide cannot run together, but are kept isolated and continue to oxidize on their surfaces, the mass being meanwhile kept "open" or porous by the inert, infusible material, to allow the rapid passage of air through the mass. This is the principle of "pot roasting"—the most radical improvement of recent years in the metallurgy of lead.

Problem 122.

A Savelsberg "pot roaster" treats 5 tons of ore mixture, consisting of 100 parts lead ore, 10 parts quartzose silver ore, 10 parts spathic iron ore, 19 parts limestone. The lead ore is galena ore, containing 78 per cent of lead and 15 per cent of sulphur; the silver ore may be called silica sand; the spathic iron ore FeCO³; the limestone CaCO³. The mixture is moistened with 5 per cent of its weight of water. Air blast is kept constant at 7 cubic meters per minute, blower displacement at 15° C., and the operation lasts 18 hours, leaving 2 per cent of sulphur in the product, which may be assumed as undecomposed PbS. Gases produced contain approximately 10 per cent of SO² and 5 per cent free oxygen; 50 kg. of charcoal is used to start the operation, and is assumed to be pure carbon.

Required:

- (1) The weight of product and its percentage composition.
- (2) The complete analysis of the gases escaping.
- (3) The efficiency of delivery of the blower.
- (4) The proportion of the heat generated by the oxidation of the ore which is absorbed in the decomposition of the limestone.
- (5) The proportion of the heat generated in the pot used in evaporating the moisture of the charge.

TABLE SHOWING COMPARATIVE RESULTS.

	Steam.	Produced Gas.	Natural Gas.	Oil.	Electricity
Total cost of installation	\$114,500	\$160,000	\$115,500	\$181,000	\$40,800
OUTPUT IN KW-HOURS PER YEAR 6,200,000					
Fuel or energy required for 1 kw-hour at switchb. and.....	3 lbs. of coal.	1.9 lbs. of coal.	18 cu. ft. of gas.	0.21 gal. of oil.	1.54 hp-hour
Lowest obtainable price of fuel or energy	\$1 25 per ton.	\$1 25 per ton.	\$0.04 per 1000 cu. ft.	\$0.02 per gal.	\$16 per 1 hp-year.
Fuel cost or energy cost per year.....	11,600	7,400	4,380	26,000	17,600
Labor per year.....	7,400	7,400	4,700	4,700	1,600
Petty expense per year.....	4,000	5,000	5,000	5,000	1,000
Depreciation and interest per year.....	16,000	22,400	16,200	26,300	5,700
Total cost of current at switchboard (6,200,000 kw-hours).....	39,000	42,200	30,380	61,000	25,900
Cost of current per kw-year.....	55 20	59 60	42 90	86 00	36 60
Comparative cost of current with electricity at 100 ...	151	162	117	235	100

- (6) The proportion of the heat generated in the pot carried away by the gases at an average temperature of 300° C.
 (7) Make a heat balance sheet of the whole operation.

Solution:

(1) The components of the 5-ton (= 5,000 kilos) charge are:

Galena.....	3507 kg.	Pb.....	2806 kg.	S.....	540 kg.
Silver ore.....	360 "	SiO ₂	360 "		
Iron ore.....	360 "	FeO.....	224 "	CO ₂	136 "
Limestone.....	683 "	CaO.....	382 "	CO ₂	301 "

Approximate composition of product:

PbO.....	2806 × $\frac{223}{207}$ =	3023 kg.
SiO ₂	=	360 "
FeO.....	=	224 "
CaO.....	=	382 "
		3989 "

But, since product contains 2 per cent of sulphur as undecomposed PbS, the above weight is only 99 per cent of the weight of the roasted ore, because the lead combined with this sulphur has been calculated above to PbO, and the O in PbO is only half the weight of the S in PbS. The above weight is short, therefore, by an amount equal to one-half the weight of the sulphur present, and since the latter is 2 per cent of the roasted ore the above weight is 1 per cent short. The corrected weight of the roasted ore is, therefore,

$$3,989 \div 0.99 = 4,029 \text{ kg.}$$

and its sulphur content 81 kg., corresponding to 521 kg. of lead, or 602 kg. of PbS. This leaves present, as PbO, 2,806 — 521 = 2,285 kg. of lead, equal to 2,285 × 223/207 = 2,461 kg. of PbO.

Revised composition of product:

PbO.....	2461 kg.	= 61 per cent.
PbS.....	602 "	= 15 "
SiO ₂	360 "	= 9 "
FeO.....	224 "	= 5 "
CaO.....	382 "	= 9 "
	4029 "	(1)

(2) The charge gives to the gases

H ₂ O	5000 × 0.05 = 250 kg.
CO ₂	(50 × 3.67) + 136 + 301 = 620
S	540 — 81 = 450 "

and the blast gives to the charge

$$O \ 2461 - 2285 = 176 \text{ kg.}$$

The volume of SO₂ produced from 450 kg. of sulphur, which makes 918 kg. of SO₂, will be, at standard conditions,

$$918 \times \left(0.09 \times \frac{64}{2}\right) = 319 \text{ cubic meters.}$$

The free oxygen in the gases is half the volume of the SO₂, and, therefore, will be exactly one-quarter of its weight.

The volumes of H₂O and CO₂ present in the gases, at standard conditions, are

$$H_2O \ 250 \div \left(0.09 \times \frac{18}{2}\right) = 309 \text{ cubic meters.}$$

$$CO_2 \ 620 \div \left(0.09 \times \frac{44}{2}\right) = 313 \text{ " "}$$

The nitrogen present is that in the air used, or 10/3 the weight of oxygen in the air. The latter is the weight of oxygen in the PbO of the roasted charge, plus the oxygen necessary to burn the 50 kg. of charcoal, plus the oxygen oxidizing sulphur to SO₂ and the free oxygen in the gases.

O in PbO.....	=	176 kg.
O to burn C.....	50 × $\frac{32}{12}$ =	133 "
O to burn S.....	450 × $\frac{32}{32}$ =	450 "
Free O ₂ in the gases.....	=	230 "
	Total	998 "
N ₂ corresponding.....	=	3327 "

Composition of escaping gases:

		Per Cent.
Nitrogen.....	3327 kg. = 2609 cu. meters	= 70.3
Oxygen.....	230 " = 159 " "	= 4.3
SO ₂	918 " = 319 " "	= 8.6
CO ₂	620 " = 313 " "	= 8.5
H ₂ O vapor.....	250 " = 300 " "	= 8.4

	3799	100.1	(2)
(3) Oxygen delivered by blast.....	998 kg.		
Nitrogen in the blast.....	3327 "		
Air delivered.....	4325 "		
Volume at 0° = 4325 ÷ 1.293 =	3345 cu. meters.		
	288		
Volume at 15° = 3345 × $\frac{273}{288}$ =	3529 " "		
Displacement of blower at 15°	7 × 60 × 18 = 7560 " "		
	3529		
Efficiency of blower	$\frac{3529}{7560} = 0.467 = 46.7$ per cent.	(3)	

(4) The heat generated in the oxidation of the ore consists of the heat of formation of the PbO formed, plus that of the SO₂, and less that of the PbS decomposed. This is not the complete heat balance of the whole operation, but simply that concerned with the oxidation of the galena.

Heat of oxidation of Pb to PbO

$$2285 \text{ kg. Pb.} \times 245 = + 550,825 \text{ Cal.}$$

Heat of oxidation of S to SO₂

$$450 \text{ kg. S} \times 2164 = + 993,275 "$$

Heat of formation of PbS decomposed

$$2285 \text{ kg. Pb} \times 98 = - 223,930 "$$

$$\text{Roasting heat} = + 1,329,170 "$$

The decomposition of the limestone, producing 301 kg. of CO₂, absorbs

$$301 \times 1,026 = 308,825 \text{ Cal.}$$

The proportion of the roasting heat thus absorbed is

$$\frac{308,825}{1,329,170} = 0.232 = 23.2 \text{ per cent.} \quad (4)$$

(5) The 5-ton charge is moistened with 5 per cent of its weight of water, or 250 kgs., in order to keep down the temperature. This absorbs, simply in becoming vapor,

$$250 \times 666.5 = 151,625 \text{ Cal.}$$

Which, on the heat generated in the roasting operation, is

$$\frac{151,625}{1,329,170} = 0.114 = 11.4 \text{ per cent.} \quad (5)$$

(6) If the gases pass away at an average temperature of 300°, and the air comes in at an average temperature of 15°, the gases cool off the pot to the extent of the difference between these two heat capacities:

Heat in the air entering:

$$3345 \text{ m}^3 \times [0.303 + 0.000027(15)] \times 15 = 15,225 \text{ Cal.}$$

Heat in gases escaping:

N ²	2600 m ³	×	[0.303 + 0.00027(300)]	=	861.1 Cal. per 1°.
O ²	159 m ³				
SO ²	319 m ³	×	[0.36 + 0.0003(300)]	=	143.6 "
CO ²	313 m ³	×	[0.37 + 0.00022(300)]	=	136.5 "
H ₂ O	309 m ³	×	[0.34 + 0.00015(300)]	=	119.0 "
					1260.2 "
Total = 1260.2 × 300 = 378,060 Cal.					

Proportion of the total roasting heat thus carried out:

$$\frac{362,835}{1,329,070} = 0.280 = 28.0 \text{ per cent.} \quad (6)$$

(7)	Heat Available.	Calories.
Sensible heat of air blast, at 15°.....		15,225
Combustion of charcoal.....		405,000
Net heat generated by the roasting.....		1,329,170
Total.....		1,749,395

Heat Distribution.

Sensible heat in the hot gases.....	378,060 = 22 per cent.
Decomposition of carbonates:	
Calcium carbonate.....	308,825 = 18 "
Iron carbonate.....	76,980 = 4 "
Evaporation of moisture.....	151,625 = 9 "
Sensible heat of product, at 400°.....	400,000 = 23 "
Loss by radiation and conduction.....	433,905 = 25 "
	1,749,395

Reduction of Roasted Ore.

If the roasted ore is reduced in reverberatory furnaces, the chances are that the undecomposed sulphide it contains will react with the oxide or sulphate, forming metal and SO², and thus eliminating almost all of the sulphur left in the roasted ore; this results in the formation of no matte, or at most of very little rich matte. If the roasted ore is reduced in shaft furnaces, the carbonaceous fuel and strong reducing atmosphere of the same, tend to reduce oxides to metal and sulphates to sulphides before they reach the temperature at which they can react on sulphide, thus cutting out very largely the double reaction, and throwing into matte the larger part of the sulphur left in the roasted ore. This is highly advantageous if the ore has copper in it, even if only in small amount, as the matte will concentrate the copper in it, is easily separated from the metal and the slag, and forms a valuable by-product. Since most lead ores contain some copper, enough to make it pay to save it, the roasting of these is never pushed to completion, and the reduction in low shaft furnaces, run at moderate temperature, is pursued with the object of producing a copper-iron matte. Any arsenic or antimony left in the roasted ore is likely also to form *speiss*, a compound of arsenic and antimony with iron, copper, nickel, cobalt, lead and silver, which is heavier than matte, but lighter than lead, and separates out in the cooling pots between these. It is a highly undesirable product, because of its complexity and the difficulty of satisfactorily and cheaply separating its constituents; it is always to be advised to remove arsenic and antimony as completely as possible in the roasting operation, even at the expense of removing too much sulphur, and then to supply the sulphur needed in the smelting operation by mixing with the dead-roasted ore some raw sulphide ore free from arsenic and antimony, if such can be obtained.

In calculating the charge for such a smelting operation, the roasted ore must be charged with such amounts of iron ore and limestone as will, together with the gangue of the ore and the ash of the fuel used, make an easily fusible slag. To produce such a slag is of fundamental importance, since it must melt

and become thinly liquid at the moderate temperature necessarily prevailing in a lead furnace. Experience has shown that a typical lead slag will contain about 30 per cent SiO², 40 per cent FeO and 20 per cent CaO, with 10 per cent allowed for other ingredients, such as Al²O³, etc., or in more general terms, that SiO², FeO and CaO are best present in the proportions 30:40:20. The other limitations are that a certain amount of hand-picked slag is always returned to the furnace for remelting and purification from matte, and that the fuel, coke, cannot melt more than a certain amount, say seven times its weight of inert material. With these conditions in mind, we will work out a typical smelting problem, the data for which are taken from Hofman's *Metallurgy of Lead*, page 311.

Problem 123.

A mixture of lead carbonate ore and galena (which represents pretty closely a partially roasted sulphide ore) is smelted with the addition of iron ore and limestone. The charges for the furnace consist of 1,000 pounds of burden (material to be smelted) and 150 pounds of coke (containing 10 per cent ash), and the 1,000 pounds consist of 100 pounds return slags and 900 pounds of lead ore, iron ore and limestone. The percentage composition of these materials is:

	Lead Ore.	Iron Ore.	Limestone.	Ash of Coke.
SiO ²	32.6	4.3	2.7	40.3
FeO.....	14.8	72.4	4.5	26.5
MnO.....	4.3	1.7	....	....
CaO.....	2.2	3.1	37.3	6.9
MgO.....	5.3	....	11.9	2.4
Al ² O ³	2.5	....	....	20.4
BaO.....	1.5			
ZnO.....	2.4			
S.....	4.4	The iron present in these materials is really present mostly as Fe ² O ³ and only partly as FeO, but the analysis is expressed usually as FeO in order to facilitate the slag calculations. The analyses, as given, are not expected to add up to 100.		
As.....	0.5			
Pb.....	20.7			
Cu.....	2.9			
Ag.....	0.17			

In making the calculations, assume that the slag to be produced contains SiO²:FeO:CaO in the ratio 30:40:20; that the FeO here expressed includes the MnO, calculated to its FeO equivalent, and the CaO includes the MgO, BaO and ZnO calculated to their CaO equivalent. Assume also that all the ZnO of the charge goes into the slag, all the sulphur into matte, all the arsenic into speiss, of the formula Fe²As, all the silver and lead into the lead bullion.

Requirements:

- (1) The proportions of lead ore, iron ore and limestone to be used in the 900 pounds of these to a charge.
- (2) The weight and composition of the slag formed.
- (3) The weight and composition of matte formed.
- (4) The weight and composition of speiss formed.
- (5) The weight and composition of lead bullion formed.
- (6) A balance sheet of the essential materials entering and leaving the furnace.

Solution:

(1) There are really only two unknown weights to be determined, for the sum of the three weights required is to be 900. Similarly, the ratio 30:40:20 really gives two conditions to be fulfilled, since there are practically two ratios to be worked to. The simplest method of solution is, undoubtedly, the algebraic one, letting x and y represent two of the ores, 900 — ($x + y$) the other, and then working out the weights of SiO², FeO and CaO in the slag, expressed in terms of x and y . The ratio 30:40:20 then gives us two independent equations, containing the two unknowns, and the problem is solved.

Let x = weight of lead ore
 y = weight of iron ore.
 $400 - x - y$ = weight of limestone
 15 = weight of ash of coke
 100 = weight of return slags.

Calculation of FeO Going into Slag.

Sulphur in 125 parts ore 4.4 lbs.
 Copper in 100 parts ore 2.0 "
 Sulphur united with Cu to form Cu_2S 0.7 "
 Sulphur left over to form FeS 3.7 "

56
 Iron needed to form FeS = $3.7 \times \frac{56}{32} = 6.5$ "

72
 FeO corresponding to this Fe = $6.5 \times \frac{72}{56} = 8.4$ "

56
 Arsenic in 100 parts of ore 0.5 "

280
 Iron required to form Fe_3As = $0.5 \times \frac{280}{72} = 1.9$ "

72
 FeO corresponding to this Fe = $1.9 \times \frac{72}{56} = 2.4$ "

56
 Total FeO disappearing in matte and speiss = 10.8 "
 FeO left over to go into slag = $14.8 - 10.8 = 4.0$ "

Therefore x parts of lead ore contributes to the slag:

SiO_2 0.326 x
 FeO 0.040 x
 MnO 0.043 x = 0.044 x FeO.
 CaO 0.022 x
 MgO 0.053 x = 0.074 x CaO.
 Al_2O_3 0.025 x
 BaO 0.015 x = 0.006 x CaO.
 ZnO 0.024 x = 0.017 x CaO.

The FeO equivalent of MnO is 72/71 the MnO ; the CaO equivalent of MgO is 56/40 the MgO ; of BaO is 56/141 the BaO ; of ZnO is 56/81 the ZnO . These ratios are the chemically equivalent values of these oxides, as taken from their molecular weights. Adding all these together, our lead ore contributes to the slag the equivalent of

SiO_2 0.326 x , FeO 0.084 x , CaO 0.119 x .

The y parts of iron ore similarly contributes to the slag:

SiO_2 0.043 y , FeO 0.741 y , CaO 0.031 y .

The $400 - x - y$ parts of limestone contributes likewise:

SiO_2 0.027(400 - x - y)
 FeO 0.045(400 - x - y)
 CaO 0.373(400 - x - y)
 MgO 0.119(400 - x - y) = 0.167(400 - x - y) of CaO.

Therefore, total contribution of the limestone to the slag:

SiO_2 0.027(400 - x - y), FeO 0.045(400 - x - y),
 CaO 0.540(400 - x - y).

Contribution of ash of fuel to the slag, in similar manner:

SiO_2 6.1 FeO 4.0 CaO 1.6

Adding all these together, we have in the slag.

SiO_2 30.4 + 0.299 x + 0.016 y
 FeO 44.5 + 0.030 x + 0.606 y
 CaO 487.6 - 0.421 x - 0.509 y

According to assumption, these ingredients as thus summated should bear the relations 30 : 40 : 20. We therefore have

30
 $30.4 + 0.299 x + 0.016 y = 487.6 - 0.421 x - 0.509 y$
 20
 $44.5 + 0.030 x + 0.606 y = 487.6 - 0.421 x - 0.509 y$
 40

Whence x = lead ore = 523 lbs.
 y = iron ore = 274 "
 $400 - x - y$ = limestone = 103 "

(2) With the weights of materials used, as calculated, we can calculate the weights of the ingredients of the slag as:

	Lead Ore.	Iron Ore.	Limestone.	Coke Ash.	Total.
SiO_2	170.5	11.8	2.8	6.1	191.2
FeO	20.9	108.4	4.6	4.0	227.9
MnO	22.5	4.7	....	....	27.2
CaO	11.5	8.5	38.4	1.0	59.4
MgO	27.7	....	12.3	0.4	40.4
Al_2O_3	13.1	....	....	3.1	16.2
BaO	7.8	....	....	....	7.8
ZnO	12.6	....	....	....	12.6

583.7

Percentage Composition and Check on Ratio.

SiO_2	32.8 per cent.		
FeO	39.0 "		
MnO	4.7 "	= 4.8 per cent.	FeO.
CaO	10.2 "		
MgO	6.9 "	= 9.7 "	CaO.
Al_2O_3	2.8 "		
BaO	1.3 "	= 0.5 "	CaO.
ZnO	2.2 "	= 1.5 "	CaO.

Summated SiO_2 : FeO : CaO
 = 32.8 : 43.8 : 21.9 = 30 : 40 : 20

(3) Sulphur in 523 lbs. of lead ore = 23.0 lbs.
 Copper in 523 lbs. of lead ore = 15.2 "
 Sulphur to form Cu_2S with this Cu = 3.8 "
 Sulphur to form FeS = 23.0 - 3.8 = 19.2 "

56
 Fe to form FeS = $19.2 \times \frac{56}{32} = 33.6$ "

Fes in matte = 19.2 + 33.6 = 52.8 "
 Cu_2S in matte = 15.2 + 3.8 = 19.0 "

Total weight of matte = 71.8 " (3)

Composition of matte

Cu_2S = 26.5 per cent. = Cu = 21 per cent.
 FeS = 73.5 " Fe = 47 "
 S = 22 " (3)

(4) Arsenic in 523 lbs. of lead ore = 2.6 lbs.

280
 Fe to form Fe_3As = $2.6 \times \frac{280}{72} = 9.7$ "

Weight of speiss formed = 12.3 " (4)

Composition: Fe 79 per cent.
 As 21 " (4)

(5) Lead in 523 lbs. of lead ore = 108.3 lbs.

Silver in 523 lbs. of lead ore = 0.9 "
 109.2 " (5)

Composition: Pb 99.2 per cent.
 Ag 0.8 " (5)

(6) Balance sheet of materials entering and leaving per 1,000 lbs. of burden:

Charges.	Bullion.	Matte.	Speiss.	Slag.	Gases.
Lead Ore 523					
SiO_2 170.5	....	....	....	170.5	....
FeO 77.4	....	Fe 33.6	Fe 0.7	FeO 20.9	O 13.2
MnO 22.5	....	....	....	22.5	....
CaO 11.5	....	....	....	11.5	....
MgO 27.7	....	....	....	27.7	....
Al_2O_3 13.1	....	....	....	13.1	....
BaO 7.8	....	....	....	7.8	....
ZnO 12.6	....	....	....	12.6	....
S 23.0	....	23.0	....	....	....
As 2.6	....	....	2.6	....	....
Pb 108.3	108.3	....	....	....	....
Cu 15.2	....	15.2	....	....	....
Ag 0.9	0.9	....	....	....	....

Iron Ore 274

SiO ²	11.8	.....	.....	11.8	.....
FeO	198.4	.....	.....	198.4	.....
MnO	4.7	.....	.....	4.7	.....
CaO	8.5	.....	.....	8.5	.....

Limestone 103

SiO ²	2.8	.....	.....	2.8	.....
FeO	4.6	.....	.....	4.6	.....
CaO	38.4	.....	.....	38.4	.....
MgO	12.3	.....	.....	12.3	.....

Ash of Fuel 15

SiO ²	6.1	.....	.....	6.1	.....
FeO	4.0			4.0	
CaO	1.0			1.0	
MgO	0.4			0.4	
Al ₂ O ₃	3.1			3.1	

Return Slag 100

109.2	71.8	12.3	683.7	13.2
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THE ELECTROMETALLURGY OF LEAD.

As far as the present, the use of electrical methods in the metallurgy of lead has been confined to the Salom process of cathodic reduction of galena and the Betts process of refining crude lead bullion. Electrothermic methods of smelting, and even of roasting, are among future possibilities, as are also the leaching by suitable solvents and electrical precipitation of lead from the solutions, but they have not been commercially practiced.

The Salom process puts the powdered galena on a "hard-lead" plate, in a solution of dilute sulphuric acid, and using a "hard-lead" anode, passes a strong current through, reducing PbS *in situ* to Pb with formation of H²S (with some hydrogen) at the cathode and oxygen at the anode. It was run commercially on a fair scale at Niagara Falls. For further details reference may be made to *Transactions American Electrochemical Society*, Vol. I, p. 87; II, p. 65; IV, p. 101.

The Betts process consists in using impure lead as anode in a solution of lead fluo-silicate, Ph², SiF⁴, strongly acid with HF. The refining plant and its operation are quite similar to a copper refining plant. The cathodes are sheet steel, greased, and the dense sheet lead deposited is stripped off from time to time.

Problem 124.

In a Salom apparatus powdered galena, density of powder 3.5, is placed in a layer 0.5 m.m. thick on a revolving lead table having an effective treatment area of 2.25 square meters. Current density 330 amps. per square meter of cathode surface. Time of treatment of the layer 90 minutes. Electrolyte dilute H²SO⁴. Resistance of cell 0.007 ohm. Heats of formation: (Pb, S) 20,300; (H², S) 4,800 (as gas); (H², O) 69,000. Assume reduction to Pb complete.

Required:

(1) The efficiency of application of the amperes passing to the reduction of the galena, and the percentage of ampere efficiency lost by the evolution of hydrogen.

(2) The average composition of the gases coming from the cell and their volume at normal pressure and 20° C., per hour. Assuming the electrolyte saturated with H²S, H² and O² at starting.

(3) The working voltage absorbed, if the efficiency of reduction of galena were 100 per cent.

(4) The working voltage if the cell were kept running after all the galena was reduced.

(5) The average working voltage of the cell in actual operation and the distribution of this.

(6) The proportion of the power required by the cell which could be generated by burning the gases produced in a gas engine (if such were possible) at a thermo-mechanical efficiency of 100 per cent.

(1) Current used $2.25 \times 330 = 742$ amperes.

Lead theoretically reducible in 90 minutes

$$0.0001035 \times 103.5 \times 60 \times 90 \times 742.5 = 429\frac{1}{2} \text{ grams.}$$

Galena in the apparatus:

$$2.25 \times 10,000 \times 0.05 \times 3.5 = 3938 \text{ "}$$

Lead under treatment:

$$3938 \times \frac{207}{230} = 3410 \text{ "}$$

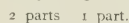
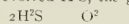
Ampere efficiency of the treatment:

$$\frac{3410}{429\frac{1}{2}} = 0.794 = 79.4 \text{ per cent.}$$

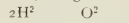
Per cent. of amperes evolving hydrogen

$$= 20.6 \text{ " (1)}$$

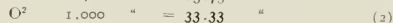
(2) If all the current evolved H²S, the gases evolved would be:



If all the current evolved H², the gases would be:



If 79.4 per cent. of the current evolves H²S and 20.6 per cent. hydrogen, the average gases evolved will be:



The volume evolved per hour is found as follows:

Oxygen produced by 1 ampere hour

$$0.00001035 \times 8 \times 60 \times 60 = 0.29808 \text{ grams.}$$

Produced by 742.5 amperes, in one hour

$$\times 742.5 = 221.3 \text{ "}$$

Volume at 760 m.m. and 0° C.

$$221.3 \div 1.44 = 153.7 \text{ litres.}$$

Volume of gases produced per hour

$$153.7 \times 3 = 461. \text{ "}$$

$$= 0.461 \text{ cubic meter.}$$

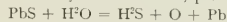
Volume at 20°

$$0.461 \times \frac{273 + 20}{273} = 0.495 \text{ " (2)}$$

(3) Voltage for ohmic resistance

$$0.001 \times 742 = 0.742 \text{ volts.}$$

Chemical work done if only H²S is formed, per formula



$$- 20,300 - 69,000 + 4,800 = - 84,500 \text{ Cal.}$$

Per chemical equivalent concerned

$$= - 42,250 \text{ "}$$

Voltage absorbed in chemical work

$$42,250 \div 23,040 = 1.83 \text{ volts.}$$

Total voltage drop in the cell

$$1.83 + 0.74 = 2.59 \text{ " (3)}$$

(4) Chemical work done if only H² is liberated = 69,000 Cal.

Voltage absorbed in chemical work

$$\frac{69,000}{23,040} = 1.49 \text{ volts.}$$

Total voltage drop in the cell

$$= 2.23 \text{ " (4)}$$

(5) Voltage absorbed in chemical work if 79.4 per cent. of the current evolves H²S and 20.6 per cent. H²:

$$(1.83 \times 0.794) + (1.49 \times 0.206) = 1.76 \text{ volts.}$$

Total voltage drop, in average running

$$= 2.50 \text{ " (5)}$$

Logically, the 1.76 volts absorbed in chemical decomposition in average running is properly calculated thus, from the energy involved:

$$(42,250 \times 0.794) + (34,500 \times 0.206) = 1.76$$

$$23,040$$

(6) Heat of combustion of 1 cubic meter of the average gas:

$$\text{H}^2\text{S} \quad 0.5203 \text{ m}^3 \times 5,513 = 2918 \text{ Cal.}$$

$$\text{H}^2 \quad 0.1373 \text{ m}^3 \times 2,614 = 359 \text{ "}$$

$$\text{Sum} = 3277 \text{ "}$$

Calorific power of gas produced per hour:

$$3277 \times 0.461 = 1511 \text{ Calories.}$$

Watt hours producible from this at 100 per cent. thermo-mechanical efficiency.

$$1511 \div 0.860 = 1757 \text{ watts.}$$

Current used by the cell, average running:

$$742.5 \times 2.50 = 1856 \text{ watts.}$$

Proportion theoretically regainable:

$$\frac{1757}{1856} = 0.95 = 95 \text{ per cent.} \quad (6)$$

The reason why more power is theoretically regainable than is used in doing chemical work in the cell, is that the gas engine burns the sulphur of the PbS ultimately to SO_2 , and this is the source of great energy, while only a relatively small amount of energy was necessary to convert the PbS into H_2S ready for combustion.

Problem 125.

Lead bullion refined by the Betts process is 96.73 per cent lead, and the refined lead is practically pure. The anodes are 1.5 inches thick, and weigh, with lugs for suspension, 275 pounds. They are left in the tanks an average of nine days, running with 135 amps. per plate, whose active surface is 1,700 square inches. Space between anode and cathode 1 1/6 inches, specific resistance of solution 10 ohms. Each tank has twenty-two anodes and twenty-three cathodes, and produces an average of 545 pounds of lead per day. Power costs \$50 per electric horsepower-year, as delivered to the tanks. Drop per tank, due to resistance of contacts, 0.15 volt; specific gravity of pure lead, 11.35.

Required:

- (1) The weight of lead theoretically deposited by the current per day.
- (2) The ampere efficiency of the deposition.
- (3) The voltage drop per tank.
- (4) The amount of anode scrap to be remelted in percent of the total anode weight.
- (5) The average thickness of the cathode deposit per day.
- (6) The power costs per ton of impure lead refined.

- (1) Lead theoretically deposited by 1 ampere per day

$$0.00001035 \times 103.5 \times 60 \times 60 \times 24 = 92.55 \text{ grams.}$$

Per anode per day, dissolved

$$\frac{92.55 \times 135 \div 1000 = 12.5 \text{ kg.}}{= 27.5 \text{ lbs.}}$$

Per tank, per day, deposited

$$27.5 \times 22 = 605 \quad (1)$$

- (2) Efficiency of deposition

$$\frac{545}{605} = 0.90 = 90 \text{ per cent.} \quad (2)$$

- (3) Amperes used per plate

$$135$$

Current density per square inch

$$= 135 \div 1700 = 0.0794 \text{ amperes.}$$

Current density per square centimeter

$$= 0.0794 \div 6.25 = 0.0127 \quad "$$

Distance of plates apart

$$= 1.17 \text{ inches.}$$

Resistance of 1 c.m. cube of electrolyte

$$= 10 \text{ ohms.}$$

Voltage drop in electrolyte

$$10 \times 2.93 \times 0.0127 = 0.37 \text{ volt.}$$

Voltage drop in connections

$$= 0.15 \quad "$$

Total voltage drop per tank

$$= 0.52 \quad " \quad (3)$$

- (4) Dissolved from anode in 9 days

$$545 \div 22 \times 9 = 223 \text{ lbs.}$$

Anode corroded in 9 days, assuming slime to fall off it

$$223 \div 0.9673 = 231 \quad "$$

Anode scrap = 275 - 231

$$= 44 \quad "$$

Percentage of anode scrap

$$\frac{44}{275} = 0.16 = 16 \text{ per cent.} \quad (4)$$

- (5) Deposit of lead on one side of a cathode, per day

$$545 \div 44 = 12.4 \text{ lbs.}$$

$$= 5.636 \text{ kg.}$$

Area of 1 side of a cathode

$$= 850 \text{ sq. inches.}$$

$$= 5312 \text{ sq. c.m.}$$

Deposit, per day, per sq. c.m.

$$5636 \div 5312 = 1.06 \text{ grams.}$$

Volume of this deposit

$$1.06 \div 11.35 = 0.093 \text{ c.m.}$$

Therefore thickness deposited per day = 0.93 m.m. (5)

- (6) Bullion refined, per tank, per day

$$545 \div 0.9673 = 563 \text{ lbs.}$$

Power required per tank

$$2070 \times 0.52 = 1076 \text{ watts.}$$

$$= 2.06 \text{ E. H. P.}$$

Cost of power per year

$$= 50 \times 2.06 = 103 \text{ dollars.}$$

per day

$$= 103 \div 365 = 0.28 \quad "$$

per ton of lead treated

$$0.28 \times \frac{2000}{563} = 0.99 \quad " \quad (6)$$

Melting, Heating, Dissolving and Eluting.

By OSKAR NAGEL, PH. D.

MELTING APPLIANCES.

Melting can be performed with direct firing, gas firing, or by means of hot water or steam, and also under pressure. As an example of direct firing, we give the description of a reverberatory melting and roasting furnace as used in the chemical industries.

As usually constructed, the hearth is built on one or two planes or steps, arched over with firebrick, upon which layers of ashes, sand, etc., are placed to prevent radiation of heat, the whole bound together with rails, securely tied with rods, both laterally and longitudinally. (Fig. 1.)

If two planes are provided in such a furnace the upper one is used for preheating, the lower one for melting the product.

A number of working doors are built into the sidewalls, through which the material is stirred and worked with hoes, paddles, etc. The material, in its passage through the furnace, travels toward or against the flame and is thus exposed to a gradually increasing temperature.

The doors are provided with rollers, which assist the operator in rabbling or working the material toward the discharging end, and are so placed that no two are opposite each other; this, in connection with the construction of the openings, renders all portions of the hearth readily accessible.

The advantage of the hand-stirred reverberatory furnace is that its first cost is small; the disadvantages are that heating is expensive, and the results obtained are irregular. Naturally the hot products of combustion can be further utilized for heating evaporating pans, etc.

The capacity of these hand-worked furnaces being not very large, it is, in many cases, necessary, especially for working large quantities, to use mechanically-driven melting or roasting furnaces, which, according to local conditions, and according to the cost of fuel, can be arranged either for coal-gas firing or producer-gas firing.

One of the best known types of these mechanically-driven furnaces is shown in Fig. 2. It consists of a horizontal cylinder of boiler iron, lined preferably with firebrick, the cylinder resting on friction rollers and revolving between a fire-box and a flue. The flame from the fire-box passes directly through the cylinder, and thence, mixed with the gases that are eventually generated by the heated material, into a dust chamber (if the latter is necessary) and to the stack. The cylinder is provided with manholes for receiving and discharging the material.

The cylinders are made to revolve slowly, the smaller ones by applying power to a shaft carrying the friction rollers, the large ones by a pinion which engages a spur gear surrounding the cylinder. The fire-box is made either movable or sta-

tionary. In the former case it is constructed in the form of a car running on a track, usually placed at right angle to the axis of the cylinder and having a short flue on one side that comes exactly opposite the throat of the furnace. In this way

and Chisholm, Matthew & Co., Colorado Springs, Col. Details of special roasting furnaces (as distinguished from smelting furnaces which are also used for roasting) will be given in a later article.

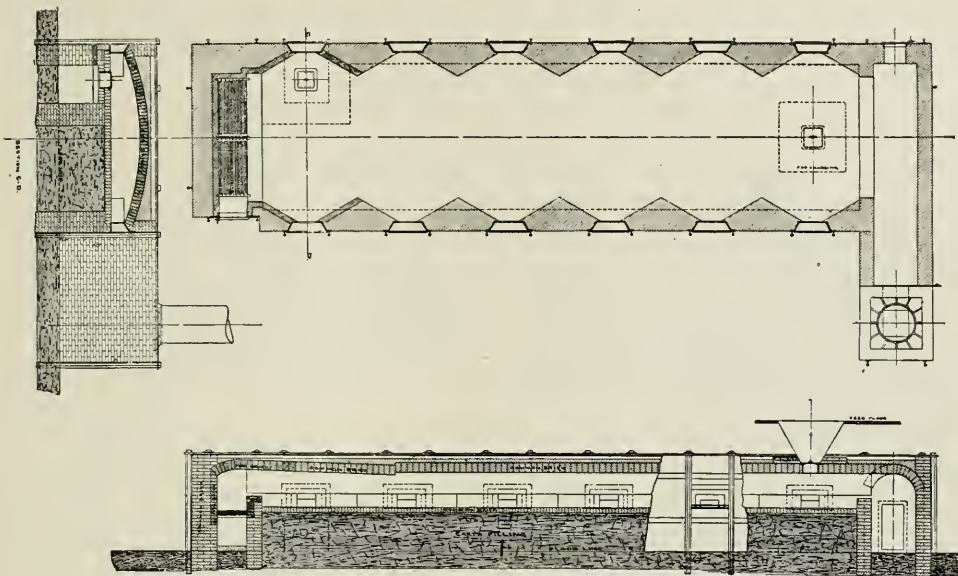


FIG. 1.—MELTING FURNACE.

the fire-box can be run in front of a cylinder containing a fresh charge and fired until the charge is melted down, or (in case of a roasting furnace) until the sulphur is thoroughly ignited and then run opposite another cylinder.

If the products to be melted are heated by means of steam, hot water, etc., the apparatus are so arranged that the products do not come in contact with the steam, and that the transmission of heat takes place as in steam boilers through the walls of the vessel.

This is done (as will be described later in detail) by using a double wall and filling the space between these two walls with steam or any other heat carrier, or by arranging steam coils inside the vessel.

The latter construction is, as far as the economy of heat is concerned, to be preferred to the former; but the attendance of this apparatus is more inconvenient, as the coils are frequently interfering with the complete removal of the charge.

These apparatus are made in various shapes, cylindrical, conical, egg-shape, etc. If liquids are to be heated to a temperature above their boiling point, i. e., if the work is carried out under pressure, especially constructed apparatus are used, which are called digesters.

(Fig. 4) Digesters, like many apparatus used in chemical engineering, are generally built to order, according to the designs of the chemical engineer of the firm which places the order.

These are cylindrical or spherical vessels, which are, corresponding to the pressure generated, of heavy construction and generally provided with a removable cover on top, which al-

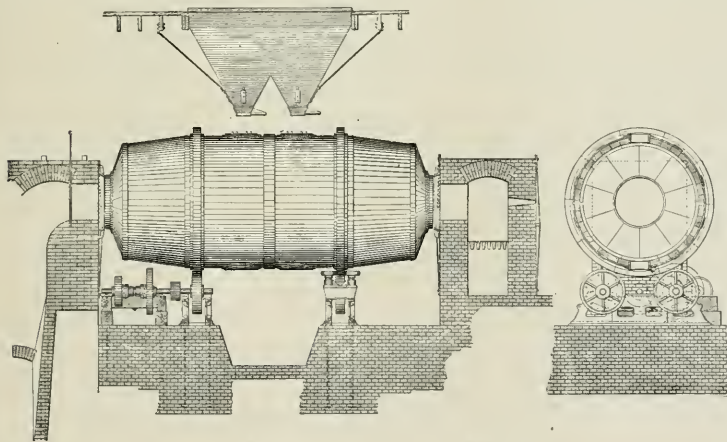


FIG. 2.—MECHANICALLY-DRIVEN MELTING FURNACE.

If it is desired to use producer-gas firing instead of coal firing, a gas producer in place of the fire-box is connected with the furnace.

There are also in use melting and roasting furnaces built similar to Fig. 1, but provided with mechanical stirrers.

Furnaces of this kind are built by the Allis-Chalmers Co., Milwaukee, Wis.; F. M. Davis Iron Works Co., Denver, Col.,

flows the cleaning and inspection of the interior space of the apparatus.

The digesters are further provided with charging openings, safety valve, thermometer tube and manometer and are heated by means of steam or direct fire. The latter heats either the walls direct, or if a double wall is used, the heat-transmitting substance, water, oil or alloys.

It is frequently necessary to use digesters, which are provided with stirrers.

As regards the materials to be used in the construction of digesters, it is obvious that they have to be selected according to the properties of the substance to be treated in the ap-

ing space is utilized for preheating the combustion air, whereby the temperature of the heating flame and its capacity for heat radiation are increased.

The heating of an evaporating pan, effected by local circulation of the fire-gases, insures the greatest uniformity in heating, long life of the pan, no warping of the material (cast iron), great capacity and low fuel consumption. It also prevents the formation of crusts.

Solid, liquid or gaseous fuel can be used in this furnace; in the furnace shown in the illustration gas firing is used, which is very suitable in most cases.

The gaseous fuel goes through flue *g* to the furnace, is mixed with the air (coming through flue *l*) in chamber *R*, travels as flame through flue *f* into the calcining space and is finally escaping through the chimney. The exchange of heat between the calcining space *C* and the evaporating pan *A* is effected by the channels *c*₁, *c*₂, *c*₃ already mentioned; for increasing the heat of the pan, if required, there are also provided openings in arch *G*, which can be closed or opened (for decreasing and increasing, respectively, the heat). The openings of the channels *c*₁, *c*₂, *c*₃ can also be regulated by means of firebricks. The material to be calcined is transported from

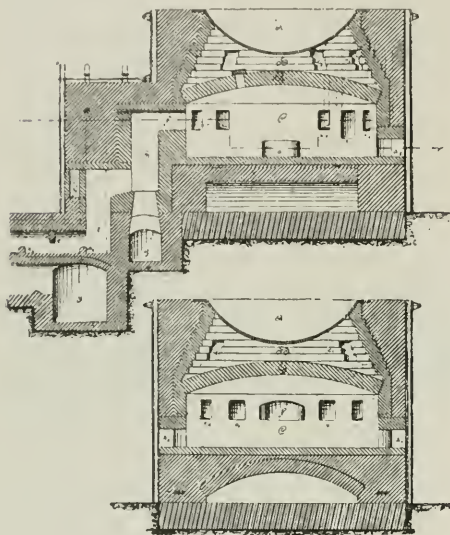


FIG. 3.—SIEMENS CALCINING AND EVAPORATING FURNACE.

paratus; digesters made of cast iron are most frequently used; if necessary they are lined with lead or provided with an enameled lining. Wrought iron and copper are only rarely used.

These apparatus, which are built in various sizes, require, on account of the danger of the operation, special care in the making. Hence a special brand of cast iron is used for preparing these castings; the bolts are made out of rivet steel. Before being used these apparatus are being tested at a pressure of 100-200 atmos., depending on the pressure which they will have to stand in the regular operation.

The glowing of products is generally carried out in similar furnaces as the melting and is called calcination in the chemical industries.

Calcination is used for removing certain substances, for instance, water, from a material by means of heating. The furnace shown in Fig. 1 and also shaft furnaces are used for this purpose. Sometimes cast-iron retorts are used for calcining.

A very durable and very economical construction of a calcining and evaporating furnace is shown in Fig. 3. (Designed by Friedrich Siemens, in Dresden.) In this furnace the radiant heat of the active flame comes into effect only in the calcining space below the evaporating kettle. The neutral products of combustion are also taken off from this space *C*, so that the evaporating pan *A* is heated only by local circulation of the firing, which is effected by connecting channels *c*₁, *c*₂, *c*₃ provided between the calcining hearth and the pan in the space *H*.

The heat of the products of combustion leaving the calcin-

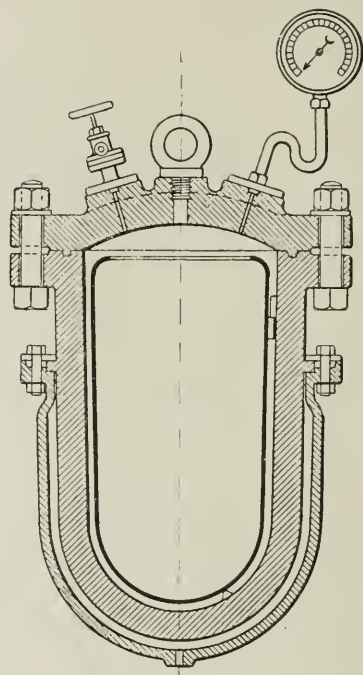


FIG. 4.—DIGESTER.

the pan to the calcining space by means of inclined planes in the brickwork; it is distributed and worked through the working doors *a*₁, *a*₂.

DISSOLVING AND ELUTING APPLIANCES.

The new product obtained by melting sometimes consists of several substances of various composition, and thence it is necessary to treat these molten masses further for separating their components. This treatment depends entirely upon the property of the molten mass; if the latter is perfectly soluble, it is treated with a liquid until it is completely dissolved, and then the individual components of the solution so obtained are separated by various methods.

If the molten mass is only partly soluble a solution is also made in a suitable solvent and the solution obtained is separated from the insoluble solid components by operations, such as filtering, etc.

According to the solubility of the mass, various methods are used for effecting a complete recovery of the soluble components.

Wherever water of ordinary temperature can be used, this naturally will be done, but in cases where cold water is not effective, hot water or steam has to be employed. This operation can be performed in open or closed vessels, and the decision in this selection will depend on the fact whether high

waters obtained in the various stages are not separated; however, they are separated according to the specific gravity; if the solutions are to be worked up. This is done most conveniently by connecting the outlets of the respective filtering apparatus with a main pipe line, and by leading the liquids therefrom according to their specific gravity through various pipe lines to the storage vessels. The liquids of sufficient strength can now be worked up directly and the thinner liquids can be used as eluting liquor for enrichment.

The proper selection of the eluting or washing arrangement, and the limit to which these operations are carried on, is frequently one of great importance for economy.

The materials used in the construction of these apparatus depend upon the properties of the solution; the construction and operation of these apparatus, again, depend upon the materials.

A dissolving and eluting apparatus, which is widely used in the inorganic industries, is the apparatus of Shanks, which is based upon the fact that the specific gravity of a solution increases with its concentration, and that a column of a weak solution is kept in equilibrium by a lower column of a stronger solution. The tanks are arranged on the same level; water, passing through the tanks is dissolving or eluting the material and is getting constantly more and more concentrated. The column of the liquid is decreasing from tank to tank, from the first, which contains pure water, to the last, from which the concentrated solution is running off. The tanks are provided with a false bottom F (Fig. 5), made of perforated sheet iron. A pipe T open at both ends, and having a diagonal section at the bottom is reaching from the bottom of each tank to the surface. Each pipe T is provided at the top with a short pipe t, connecting one tank with the other. By means of the water pipes r each tank can be filled with water. The solution is discharged through cocks R. For crude soda ash, four washings are generally sufficient.

An apparatus for dissolving materials without the use of direct steam (Fig. 6) is built by Werner & Pfeiderer, Saginaw, West Side, Mich. In this apparatus the material to be treated is drawn with the liquid by means of a tangential wheel into the interior of the same, and is thrown out sideways with great force. As the material passes through the interior of the tangential wheel, up the wall of the egg-shaped trough, and in the axis of the trough to the tangential wheel, there are many changes of motion which result in an energetic treatment of the material.

Heat-Insulating Materials.

In *Stahl und Eisen*, of Nov. 20, Dr. STEGER discusses the important problem of providing a good heat insulation for metallurgical furnaces and apparatus.

The simplest heat insulator is non-circulating atmospheric air. But the method of enclosing an apparatus within a double jacket, with a sufficient space of air between the walls, is not always applicable. As a substitute it is possible to use porous bodies, brick containing numerous holes and pores filled with air.

The manufacture of porous brick from kieselgur (infusorial earth) has long been known. The kieselgur, mixed with a binding material like clay or water glass, is formed into brick and burnt. Care must be taken in burning, since too much heat causes sintering and the heat-insulating property is lost. A properly treated brick of 250 mm. (9 $\frac{7}{8}$ inches) length may be heated to red heat at one end, while the other end is heated so moderately only that it is possible to touch it with the hand.

Since kieselgur is not everywhere available at a sufficiently low price, heat-insulating brick has been made from other materials which are *per se* better conductors of heat, but which are provided artificially with numerous pores. For this purpose, for instance, an intimate mixture of clay and finely divided organic substances is used. The latter burn, when the

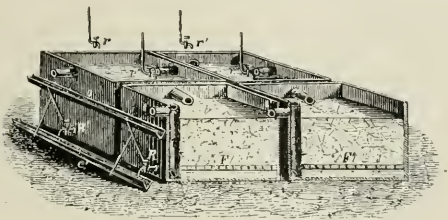


FIG. 5.—SHANKS APPARATUS.

steam pressure is required, and, if during the solution, detrimental vapors are generated.

In many cases, in place of water, a dilute solution of the substance to be recovered will be used, as thereby the same is gradually concentrated, which means a considerable saving of coal in the evaporation, eventually to be performed for final concentration.

For increasing the velocity of the dissolving process and for obtaining solution nearer to the point of saturation in open and closed vessels, stirrers are used similar to those used in mixing machines.

Vertical stirrers are to be preferred to horizontal ones, as in the latter the stuffing boxes of the shaft are exposed to a considerable wear, partly because they are always in the solution, coming continuously in frictional contact with the solid particles contained in same, and partly as the entire pressure of the stirrer against the mass, and the weight of the stirrer has to be absorbed and carried by them. A further disadvantage of the horizontal construction is the more expensive cost of repairs.

In vertical stirrers only one stuffing box is required, which is provided on the top, and which, in closed vessels, has to be only steam tight, as the solution does not come up so far.

The residuum obtained by the separation of the insoluble solid substances from the liquid (by simple filtering, centrifugals, etc.) contains generally so many liquid particles still enclosed that the recovery of same is of advantage, and in some cases even absolutely necessary.

Hence in filter-presses the residuum is washed by means of water, diluted solutions of the respective liquid or by other liquids, either until the residuum is of the purity required or as long as the wash-waters obtained allow an economical using over of same.

Similar conditions prevail with material obtained by centrifugals.

As will be described in another article, special arrangements are made on filter-presses for eluting purposes.

If only the solid components are to be recovered, the wash-

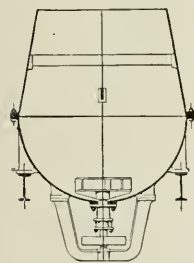


FIG. 6.—DISSOLVING APPARATUS.

brick is heated, under the action of the atmospheric air which enters into the mass through the many cracks which form. There are thus produced innumerable pores within the mass. Suitable materials to be added to the clay are finely divided peat, bituminous coal, sawdust, straw, wool waste, tar, etc. They are added to the clay mud as a very fine powder, and the mass is very thoroughly stirred and mixed to make sure that the pores are uniformly distributed throughout the mass. The clay must be "fat," so as to be able to absorb a large quantity (up to 75 per cent) of organic additions. These additions contribute to the thorough burning of the clay and thus reduce the amount of fuel required.

If such brick is to be used for refractory linings at very high temperatures, not only a good refractory clay, but such additions should be chosen which contain very little ash. The purest brick is obtained from such clay masses, to which is added a substance which evaporates completely, like naphthalene, resin, tar or ammonium carbonate. But these materials are expensive and means should be provided to recuperate them; for this purpose the brick, before being burnt, should first be moderately heated in a muffle furnace so that the evaporating materials distill off and are recovered.

"Under certain conditions it may be advantageous to burn out the added organic substance not entirely, but only partly, so as to gain not only porosity, but also strength. The zinc companies' in Western Germany add throughout ground coke to their retort mass. This addition amounts to only 10 per cent, but gives a very dark color to the mass. The retorts when pressed receive a glaze cover which melts in the furnace fire and prevents the burning of the coke particles. Bischof (Die feuerfesten Tone, 1895, page 266) says concerning this addition of coke to clay: 'If a clay contains considerable carbon, the carbon which is present or which is absorbed from the fire gases, as long as it is not burned out, prevents the clay from melting. Any slag or clayey mixture may be made more refractory for a certain time in this way by an addition of carbon.' The same author says (p. 292): 'Anthracite, then coke, and still more charcoal are much more liable to be inflamed and burn off than graphite, but as long as they are enclosed within clay and do not burn out, they make the clay more refractory and less liable to crack. These quotations confirm the experience that from clayey masses, to which coke, anthracite or other kind of coal is added, bodies can be obtained by careful burning, the oxidizable constituents of which are only partly removed and which are therefore at the same time porous and stand higher temperatures and are less liable to crack than the clayey mass alone.'

Brick which is dense on one surface, but otherwise porous, is made by pressing a thin layer of clay and chamotte, then putting on it clay of the same quality and the same content of water, but mixed with an oxidizable material, for instance, sawdust, pressing again, drying and burning. The sawdust burns out. Such brick is an excellent insulator for metallurgical furnaces.

The highest degree of porosity in brick can be obtained by combining the methods, *i. e.*, by mixing kieselgur and organic substances with very small quantities of binding materials like clay or water glass. During the burning the inserted organic substance prevents the mass from sintering together and becoming dense and compact. After the organic substances are burned out it becomes necessary to take care in maintaining the proper temperature. The finished brick has both the pores due to the burned-out organic substances and the natural pores of the kieselgur. Of special advantage is the addition of very finely powdered cork with kieselgur. Cork contains innumerable pores, even in the smallest particles. If it is desired to

have in the product regular channels running in certain directions, then thin wooden rods or threads are placed in proper distances from each other, which later burn out.

Very suitable as a heat-insulating brick, for instance, for roof construction, are hollow blocks. Thus Houldis brick, which is much used in Southern Europe as an insulating brick, is 25 cm. (9.78 inches) broad, 6 to 10 cm. (2.36 to 4 inches) high, and 50 to 100 cm. (1 foot 8 inches to 3 feet 3 inches) long, but the thickness of the walls is only 7 mm. (a little more than 1/4 inch). Thin partitions pass through the hollow spaces so that a number of channels of square cross-section are formed.

This brick is made from clay which contains a certain amount of magnesia, about 5 per cent, and 7 to 8 per cent of iron oxide and 12 per cent lime. Although this brick is made from a clay, which is not really refractory, it stands temperatures up to 1,000° C.

For higher temperatures it becomes necessary to use good special clay for making the brick, and it is advisable to make the thin walls of these hollow blocks porous in the manner described before. To increase the strength of the blocks they may be made dense and non-porous on the outside.

By putting together a series of hollow blocks, channels can be made for special purposes; for instance, for getting pure, hot dry air.

The use of hollow and porous brick of light weight reduces the cost of erecting light structures. This brick is also useful for damping sound.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

THE PRODUCTION OF POWER FROM PEAT.

The inaugural address, delivered by the chairman of the Dublin local Section of the Institution of Electrical Engineers, dealt with a scheme of utilization which makes 60 per cent of the total heat derived from the peat available for the necessary drying; and this, from an engineering point of view, makes it possible, when the value of the ammonium sulphate obtained covers the cost of preliminary operations.

If 85 pounds of ammonium sulphate be obtained from 1 ton of dry peat, 1 ton would be yielded by 26 1/2 tons, the respective values being £12 (less value of sulphuric acid), and 7s. and 11d.,—say, 7s.—or 3s. per ton of peat containing 40 per cent of moisture, which is approximately the amount in air-dried peat.

A means is sought of obtaining peat equal to the air-dried at 3s. per ton. In Ireland air-dried peat cannot be produced for this sum.

There are various devices. The Bromsowsky machine is said to yield 2 tons of peat "cut and laid to dry" per man per day; labor thus costing 1s. 6d. per ton. This is a hand-worked machine. The Anrep, a Swedish machine, is more elaborate and deals with twelve times as much, at a cost of 3s. 4d. per ton of dry peat; but the power absorbed is excessive. The Schlickeysen, or Dolberg, machine was also mentioned. The first of these machines gathers peat containing a natural quantity of moisture, according to the season, working best, of course, in normal summer and early autumn. The second macerates and forms the peat in briquettes containing 80 per cent of moisture. The last also macerates and presses and delivers the peat with 50 to 60 per cent of moisture, but appears to be encumbered with undesirable complications; yet it has good points which more than compensate.

The question of utilization of waste heat sufficiently to expel the residual moisture was then gone into. From 100 pounds of dry peat 864,400 B. T. U. are evolved; 648,000 in the

¹ It should be emphasized that in the case of retorts for zinc distillation the object is not to get a good heat insulator, but just the opposite, to get a good heat conductor, since the heat is to be transferred from the outside to the inside of the retort. The ideal material for a zinc retort should be highly refractory and resistant to the chemical attack to which it is subjected, and, at the same time, a very good conductor of heat.—Ed.

gases. If these gases were employed in a gas engine of 30 per cent thermal efficiency, 454,000 units are lost and absorbed in the exhaust and the cooling water, leaving 194,000 units available for power.

Can this be realized? The data appear to indicate that the efficiency is 45 per cent; and "practical efficiency" is said to be 36 per cent.

The address also dealt with the heat necessary to raise steam for the producer and that required to concentrate the ammonium sulphate, and concluded by drawing attention to difficulties which have arisen through past failures.

THE DAVY CENTENARY OF THE FARADAY SOCIETY.

There was a good attendance at the ordinary meeting of the Faraday Society, which was held at the Institution of Electrical Engineers on Tuesday, Dec. 17, 1907, when Dr. F. G. Donnan read a very interesting paper by J. T. Barker, B. Sc., illustrated by lantern slides, on "A Physico-chemical Study of the Complex Copper-Glycocol Sulphates," which, although mainly of interest from a chemical point of view, yet opened up a new vista of the correlation of the forces.

Dr. F. Mollwo Perkin then read a most valuable paper on the discovery of the alkali metals by Humphrey Davy and its bearing on industry.

The Davys originally came from Norfolk, but settled later in Cornwall, where Edmund Davy, the grandfather of Humphrey, was a builder, and his son was named Robert, who, apparently thriftless, died, leaving his affairs in a complicated state when Humphrey was only 16. He at once realized his family duties, studied hard, and very soon was apprenticed to an apothecary and surgeon at Penzance. In 1797 he began to study natural philosophy and chemistry. Little is known of this early work. It was meeting Gregory Watt, son of James Watt, that decided Davy to devote himself to science.

In 1798, Dr. Beddoes, who had been trained as a doctor of medicine, fitted up sanatoria at Bristol, and asked Davy to take charge of his "Pneumatic Institution." Davy studied the action of gases in various ailments and gained experience with nitrogen monoxide, with which he was nearly overcome. Maria Edgeworth, a sister of Dr. Beddoes, tried this gas; and her sensations are a revelation. Davy continued experimenting until, in October, 1800, a letter to Dr. Gilbert states that he found galvanic action purely chemical, and describes the action of water and acids on zinc as well as the facts connected with polarization and recovery. On Feb. 16, 1801, he was elected to responsible positions at the Royal Institution, and his first lecture was on galvanic phenomena. His appearance was not what is termed prepossessing. Rumford said he must first lecture in a small room to rehearse, but on hearing him gave him *carte blanche*. Davy then worked on agriculture.

In October, 1807, he began to study voltaic electricity and its action on alkali compounds, and it is apparent that he seems not to have experimented very much in this way before the Autumn of 1807. His Bakerian lecture astonished his hearers by its lucid description and practical production of potassium and sodium. His first attempts were made on aqueous solutions of the hydroxides with large batteries of copper-zinc couples, using an electrolyte of nitrite acid and "alum." He recognized the fact that the presence of water interfered with the reduction, and then tried fused potassium hydroxide with 100 cells of 6-inch highly charged plates in various experiments, and obtained, what he termed, the inflammable principles of potassium and sodium.

By further research on pure materials he obtained some most remarkable results, which are fully described in the paper; and these led him to work on alkaline earths, from which he obtained amalgams by use of mercuric oxide, which he distilled, using suitable precautions against oxidation, but he seems to have had doubts as to the purity of the products.

Students of pure science can, with difficulty, appreciate the grand results this man obtained, working under great difficulties

with crude apparatus, by his own persistent efforts. He had recognition in his day; he loved applause, and had it, and his labors constitute the basis of much that modern science can demonstrate. The paper then went on to describe the progress of commercial production of the alkali metals, giving outlines of the several processes employed since 1827, and deals at some length with their chemical aspect, concluding with Darling's method (which is not in commercial use now).

MARKET PRICES, DECEMBER, 1907.

Tin opened at £133 per ton, reached £134.10 on the 6th, after falling to £125.10 on the 11th it rallied to £127.5 on the 12th, and fell to £116 on the 17th, after which it rose to £122 on the 23d, and after a slight fall during the holidays closed at £123.10.

English lead opened at £16.5, falling almost continuously until the 16th, when it reached about £13.10; it rose steadily until the 24th, reaching £15.5; the price on the 31st was £14.10.

Scotch pig iron opened at 60s. per ton and fell to 59s. 6d. on the third, at which it remained until the 10th. The 11th saw a further drop to 59s., remaining until the 13th at 59s. It dropped again to 58s. on the 16th, remaining at this figure until the 27th, and closing at 57s. 6d.

Hematite pig iron opened at 67s. 10d. per ton, fell to 67s. on the 3d, remained until the 5th, and touched 68s. 9d. on the 12th, falling to 66s. 2d. on the 16th it fell very slowly until the 31st, when 65s. 10d. was reached.

Cleveland pig iron opened at 49s. 10d., and varied from 49s. to 50s. until the 30th, when it fell to 48s. 6d.

Copper opened at about £62 per ton, and varying slightly until the 6th fell to £58.15 on the 12th, the price was £59.5 on the 13th, and after falling to £57.5 on the 17th rose to £60.10 on the 23d and closed at £62.

Other closing prices: antimony was £24 to £35 per ton; ammonia sulphate, £12.10 per ton; copper sulphate, £22 per ton; bleaching powder, 35 per cent, £4.10 per ton; white caustic soda, 77 per cent, £11.26 per ton; shellac, £6.5 per cwt.

Coal tar products: benzole, 90 per cent, 7d. per gallon; carbolic acid, liquid, 97 per cent to 99 per cent, 1s. 1d. per gallon; creosote, ordinary good liquid, 2s. 3½d. per gallon; naphtha solvent, 90 per cent at 166° C., 11d. per gallon. Pitch, £11.6 per ton.

Imports of Ferro Alloys.

The statistics of the American and Foreign Iron Trades for 1906, which has just been issued by the American Iron and Steel Association, gives the following figures as to the imports of spiegeleisen, ferro-manganese and ferro-silicon in 1904, 1905 and 1906:

ARTICLES.	1904.		1905		1906.	
	Gross Tons.	Tons. Values.	Tons.	Values.	Tons.	Values.
Ferro-manganese.....	21,814	\$707,037	52,841	\$1,844,651	84,359	\$4,953,644
Spiegeleisen.....	4,623	132,461	55,457	1,336,104	103,267	2,942,940
Ferro-silicon.....	3,691	184,229	11,044	558,906	11,863	788,085
Total.....	30,128	\$1,023,727	119,342	\$3,779,661	199,489	\$8,684,669

With respect to ferro-silicon, it is clear from the values given that the bulk of the imports was low-grade ferro-silicon.

In this connection it may be interesting to note that the price on high-grade ferro-silicon has recently also gone down to a considerable extent. While the high price last year was \$104 for 50 per cent ferro-silicon, it is now offered for \$85, while 75-per cent ferro-silicon is reported to be offered for \$127.50. In other words, the buyer pays exactly according to the silicon content alone.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

ELECTRIC FURNACES

Silicon Monoxide.—H. N. Potter, 875,675, Dec. 31, 1907. Application filed June 10, 1905. Assigned to George Westinghouse.

Silicon monoxide is made according to the equation $\text{SiO}_2 + \text{Si} = 2\text{SiO}$, so that the whole reacting mass is converted into monoxide. There is no CO gas liberated, and the absence of carbon renders it impossible to produce silicon carbide which the inventor has sometimes found in small quantities as an impurity in silicon monoxide powder. Silicon carbide is a particularly undesirable impurity, as it cannot be removed by the action of any reagent which does not attack silicon monoxide, whereas, many other impurities, such as magnesia, alumina and calcium oxide can be largely removed and iron to a somewhat lesser degree. The reaction is carried out in an electric vacuum furnace with a mixture of 28 parts of granular silicon and 60 parts of granular silica. If it is desired to avoid the presence of silicon dioxide in the product a charge having a slight excess of silicon may be used.

Silicon Monoxide Powder.—H. N. Potter, 875,676, Dec. 31, 1907. Application filed June 10, 1905. Assigned to George Westinghouse.

In making silicon monoxide the main portion is obtained in the form of a finely-divided powder, while a small portion appears in vitreous form. The powder is more useful and the vitreous monoxide may be reduced to a finely-divided powder by breaking it into granular form and charging it into an electric vacuum furnace, where it does not melt but appears to be sublimed or volatilized and driven away from the high temperature focus, cooling and settling in a finely-divided state. The vitreous monoxide, which is a by-product of silicon manufacture, may thus be used as a raw material for making the useful silicon monoxide powder.

Silicon Monoxide.—H. N. Potter, 875,286, Dec. 31, 1907. Application filed June 14, 1905. Assigned to George Westinghouse.

When silicon is highly heated in air under reduced pressure, or in an atmosphere poor in oxygen, silicon monoxide is produced. When the silicon thus heated is in a vaporous form the resulting product appears in the form of silicon monoxide powder. The crystalline metallic silicon may be piled about the graphite core resistor in a vacuum furnace, and thus heated, or the silicon may be used directly as resistor.

Silicon.—H. N. Potter, 875,285, Dec. 31, 1907. Application filed June 10, 1905. Assigned to George Westinghouse.

Silicon is produced by the reaction $\text{SiO} + \text{C} = \text{Si} + \text{CO}$. Silicon monoxide powder and finely subdivided carbon are mixed and heated in an electric furnace in the absence of free oxygen or other reactive gas.

Production of Silicon.—Henry Noel Potter, 875,672, Dec. 31, 1907. Application filed June 10, 1905. Assigned to George Westinghouse.

Silicon is produced by the reaction $\text{SiO} + \text{SiC} = 2\text{Si} + \text{CO}$. Silicon monoxide and silicon carbide are mixed in finely subdivided form and heated in an electric furnace in the absence of free oxygen or other reactive gases.

Silicon Carbide.—Henry Noel Potter, 875,673, Dec. 31, 1907. Application filed June 10, 1905. Assigned to George Westinghouse.

Silicon carbide is produced by the reaction $\text{SiO} + 2\text{C} = \text{SiC} + \text{CO}$. Finely subdivided silicon monoxide and carbon are mixed and heated in an electric furnace in the absence of free oxygen or other reactive gases.

Silicon Dioxide Powder.—Henry Noel Potter, 875,674, Dec. 31, 1907. Application filed June 10, 1905. Assigned to George Westinghouse.

Silicon dioxide in a state of extreme comminution is produced by first making silicon monoxide and then oxidizing it according to the equation $\text{SiO} + \text{O} = \text{SiO}_2$. For instance, air may be blown through an electric furnace in which silicon monoxide is being produced, or silicon monoxide powder and air are blown through a highly heated tube or through an oxidizing flame.

Silicides.—E. F. Price, 873,328, Dec. 10, 1907. Application filed Nov. 14, 1905.

The sides 1 of the furnace shown in Fig. 1 are made of carborundum, silicon or silica, or of carbon, while the hearth 2 is made of carbon, the sides and hearth being surrounded by a metal casing 3 with a terminal 3', the carbon hearth constituting one electrode.

The other electrode is the carbon rod 4. The tap holes 5 and 6 are for slag and metal respectively. An arc is established between the end of the electrode 4 and the hearth 2. The charge, consisting of finely ground silica and coke (both in relatively large proportion) and iron ore, is then gradually fed into the furnace until it is in normal working condition, when the depending electrode is embedded, as shown in the illustration. As the reduction proceeds the molten ferro-silicon collects at the bottom of the furnace and is run out through 6. The use of a charge containing a large percentage of silica makes it possible to produce silicides containing 50 per cent and upwards of silicon. Such a charge is also substantially a non-conductor of electricity, so that the working chamber of the furnace can be filled without shunting the current from the electrodes through the charge. The excess of carbon in the charge facilitates the reductions and protects the electrodes, and the continuous mode of operation enables the efficiency of the furnace to be maintained at a high figure. Metallic iron may be substituted for iron ore in the charge.

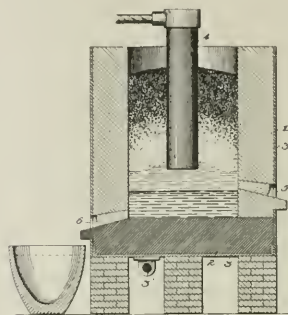


FIG. 1.—FERRO-SILICON FURNACE.

Ferro-Vanadium.—E. F. Price, 875,208, Dec. 31, 1907. Application filed Dec. 29, 1906.

Low-silicon ferro-vanadium is produced from a silicious vanadium sulphide ore in continuous operation by the following stages. The vanadium sulphide, after having been roasted and changed into vanadium oxide, is mixed with iron or iron oxide and with carbon, the latter being employed in the minimum proportion required to effect reduction. A basic flux, such as lime, is added. The mixture is then charged into the electric furnace, the electrodes of which are embedded in the charge. The furnace is provided with a carbon lining, at least at the zone of contact with the slag, and with tap-holes for the slag and alloy. Reduction is then effected and continuously maintained by passing an electric current through the charge, the zone of reduction being surrounded by a considerable body of the charge to retain the heat and protect the oxidizable electrodes and metallic product from the action of the air. The products are tapped off and the charge mixture

added as required, the slag or alloy being separated either within or outside of the furnace. The high-silicon ferro-vanadium is then treated with a suitable reagent to oxidize and remove the contained iron, preferably with an oxide of either iron or vanadium so as to introduce no metallic impurities.

Calcium Carbide Furnace.—J. C. King, 872,351 and 872,352, Dec. 3, 1907. Application filed Jan. 5, 1904. Assigned to Willson Carbide Works Co. of St. Catharines, Ltd.

The object is to produce pure carbide without crust, since the latter is practically a waste product. The construction of the furnace is shown in Fig. 2. A is a carbon pencil con-

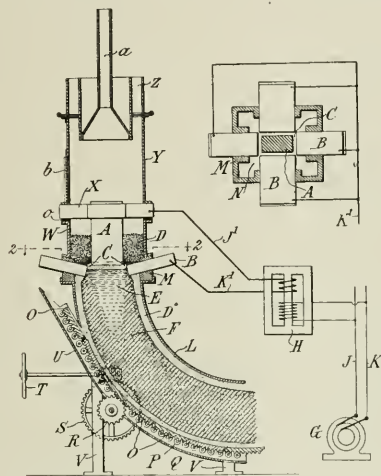


FIG. 2.—CALCIUM CARBIDE FURNACE.

stituting one of the electrodes, and B are the carbon blocks, or sections connected with each other, and constituting all together the opposite electrode. The inner ends of the carbons B are contiguous to each other, so that they form substantially a die surrounding the pencil A. The pencil A is of such size as to leave an annular space C between the opposite electrodes. It is through this annular space, across which the current continually passes, that the material D is passed, and first liquefied into a pool, as shown at E, which subsequently solidifies into a pig F of carbide. A suitable mechanism for drawing out the pig F comprises a conveyer made of sections O connected together to form a continuous curved platform running on rollers P.

Electric Furnace Control.—F. Creelman, 874,944, Dec. 31, 1907. Application filed Jan. 5, 1904. Assigned to Willson Carbide Works Co. of St. Catharines, Ltd.

To operate a furnace with constant power the inventor employs a constant current supply, that is, a constant number of amperes are passed through the furnace while the e. m. f. varies in proportion to the internal resistance of the furnace. The furnace is so regulated by hand or automatically as to restore the normal internal resistance when varied from, so as to maintain an approximately uniform internal resistance, and to thereby maintain an approximately uniform expenditure of energy or generation of heat. Thus in practical operation, whenever the internal resistance varies, the current, instead of varying in inverse proportion, remains constant, and a variation in voltage alone takes place, the normal voltage being soon restored by the regulation of the furnace, which restores the normal resistance. This is accomplished in a crucible furnace by lifting of the carbon pencil or pencils; in a rotary

furnace by the advancement of the shell carrying the reduced product, commonly in the form of a pig or ingot; or in a horizontal incandescent furnace by the separation of the conducting pencils. With respect to calcium carbide manufacture, the object is to produce the carbide without crust, and the method is similar to that described in the preceding abstract. The process may be described as a continuous tapping process, in which the zone of fusion is maintained in the tap-hole itself, the fused material being supported immediately beneath the tap-hole to uphold therein the material undergoing fusion. In practicing this process the inventor feeds or passes the entire mixture through the zone of fusion and reduction maintained between two electrodes, the interspace between the electrodes constituting the outlet or tap-hole of the furnace, and also constituting the zone of reduction. Preferably one electrode is formed as a pencil projecting into and through an opening formed in the other or annular electrode, the annular space between the two forming the interspace or tap-hole. Since none of the mixture can pass through this interspace or zone of reduction without being reduced, no crust is formed. The use of a constant current supply is necessary for this method, since with the same the electrodes are normally stationary, or are readjusted only at long intervals as they wear away, and wide but momentary fluctuations of resistance are liable to occur, due to variations of the condition of the material filling the interspace or zone of reduction.

Induction Furnace.—G. Gin, 875,801, Jan. 7, 1908. Application filed May 3, 1906.

This is the type of induction furnace to which Mr. Gin referred in his recent American Electrochemical Society paper

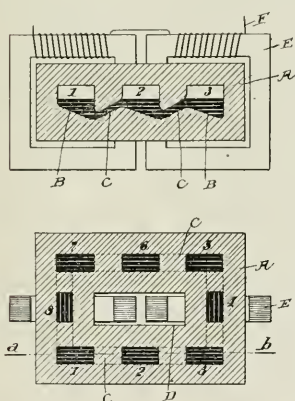


FIG. 3.—INDUCTION FURNACE FOR ZINC SMELTING.

on the use of the electric furnace for zinc production. The construction is shown in Fig. 3. The main object is to get a strong, continuous circulation of the molten material. This is obtained by forming the channel crucible of a succession of open channels or receptacles, the bottom of each being longitudinally sloping, and by connecting these channels or receptacles by means of laterally closed conduits connecting the deep end of each channel with the shallow portion of the adjacent channel. The continuous channel is indicated in the plan section of the illustration by 1, 2, 3, 4, 5, 6, 7, 8. The connection of 1, 2 and 3 together is shown in the vertical section, which is a section along the line a b of the plan section. Since the Joulean heat developed at different points of the circuit changes with the cross-section, temperature differences are produced, and therefore differences of specific gravity, which result in continuous movement. The magnetic circuit E is a double one, and the primary winding F consists of two symmetrical windings placed on the two upper horizontal arms. B and C are the fluid mass, and A is refractory material.

Carbon Bisulphide Furnace.—E. R. Taylor, 871,971, Nov. 26, 1907. Application filed Sept. 5, 1906.

In the present patent, Mr. Taylor endeavors to apply the principle of using self-moving materials in resistance furnaces,

which he has carried out so successfully on a large scale to the construction of a carbon bisulphide furnace on a comparatively small scale. The furnace has an embrasured wall of firebrick, enclosing a vertical working chamber and outer shell, and enclosing an annular feed space between the wall and the shell. Electrode stems extend downwardly within this feed space, and a pair of electrodes is attached to the lower ends of these stems. They extend into the working chamber and toward each other.

ELECTROLYTIC PROCESSES.

Electrolytic Production of Cyanides.—F. W. Morris, 871,948, Nov. 26, 1907. Application filed Dec. 28, 1906.

The process consists of two steps, the first of which is carried out in an electrolytic cell of the same construction as the Castner-Kellner cell, the anodic and cathodic compartments being connected together at the bottom by a body of mercury. The difference from the Castner-Kellner cell is that in the present case both compartments are filled with a solution of sodium or potassium formate. The result of electrolysis is the production of formic acid in the anode compartment and of caustic soda with the evolution of hydrogen in the cathodic compartment. When the circuit is broken the formic acid is neutralized by the addition of a suitable ammonium salt to the production of ammonium formate. The latter is siphoned off and is evaporated to form dry crystals or just to the point of breaking off, which point is indicated by the faint smell of hydrocyanic acid being given off. The crystallized ammonium formate is then charged into a still and quickly heated, whereby it is broken up into hydrocyanic acid and water, which are condensed in a worm connected to the still and contained in a water tank. The lower end of the worm leads itself into a receiver, charged with caustic soda or caustic potash (according to whether sodium or potassium formate is used in the original electrolysis). The interaction between the hydrocyanic acid with caustic soda or potash yields sodium or potassium cyanide, respectively.

Electrolytic Refining of Tin.—E. A. Sperry, 874,707, Dec. 24, 1907. Application filed Sept. 15, 1906.

Slag tin, dross tin or other impure tins may be electrolytically refined with an electrolyte consisting either of the sulphate or ammonium oxalate or ammonium sulphate or chloride or fluoride or hydrochloric or hydrofluoric acid. In most electrolytes the objectionable impurities, among them lead, are segregated out from the other impurities and, together with the lead, tend to deposit on the cathode along with the tin, especially at high temperatures. It is recommended to remove as many impurities in advance of electrolysis as possible. For this purpose the impure tin is molten and treated by poling. The dross, which consists in certain oxidation products of lead and also some of the other objectionable impurities, accumulates on the top and is skimmed off. During the poling operation an oxidizing agent, such as a nitrating element, may be added; for instance, saltpetre, which is very gradually introduced into the molten mass to hasten the formation of the oxidation products. It is preferable to pour the anodes at a low temperature. During electrolysis it is important to prevent the anode slimes from reaching the cathodes. For this purpose a diaphragm cell is used. The electrolyte in the anode compartment is circulated. The best temperature of electrolysis is usually slightly below 85° C. The total impurities of the product are well under 0.01 per cent. The impurities accumulate in the electrolyte and are eliminated by periodical withdrawal of portions and treatment and replacing with pure and fresh electrolyte. The treatment in this case may be illustrated in the use of stannous chloride as electrolyte. Here the electrolyte withdrawn is treated with quick-lime or milk of lime, or a suitable alkali, and the tin precipitated as tin oxyhydrate, which is utilized as

raw tin oxide, is smelted or is "roasted" and separated or concentrated to eliminate the impurities. The tin may then either be smelted or utilized as fixed oxide; the impurities in whole or part are left behind in the precipitating process. That portion thrown down with the precipitate is eliminated in the roasting or concentrating or separating process.

Production of Aluminium.—H. S. Blackmore, 872,985, Dec. 3, 1907. Application filed April 18, 1903.

Aluminium is reduced from its oxyfluoride or mixture of oxide and fluoride by electrolyzing this mixture in a carbon-lined reduction pot with a calcium carbide anode. The aluminium oxide and fluoride are melted by the current, and its fluidity may be increased by addition of calcium fluoride. The reaction is $Al_2F_6 + 2Al_2O_3 + 3CaC_2 = 6Al + 3CaF_2 + 6CO$, aluminium being set free at the cathode and calcium fluoride and carbon monoxide being liberated at the anode.

Aluminium Alloy for Steel Casting.—M. Meslans, 875,668, Dec. 31, 1907. Application filed July 7, 1902.

A metallic crucible which is connected to the negative pole of an electric circuit has sides covered with a refractory and insulating lining, while the bottom is exposed. The exposed bottom is covered by fused aluminium and above the aluminium is a layer of anhydrous calcium chloride which constitutes the electrolyte and into which carbon rods forming the anodes are suspended. A voltage of from 7 to 10 volts is employed with a current density from 100 to 150 amps. per square decimeter of the anode surface. By the action of the current calcium is set free at the cathode and alloys with the aluminium. The proportion of calcium in the alloy may be regulated at will by continuing the electrolysis for greater or less time. Aluminium-calcium alloys containing up to 95 per cent of calcium may thus be made. When the alloy becomes very rich in calcium, it detaches itself in large pieces and comes up and floats on the surface of the electrolyte, from which it is removed. Alloys of barium, strontium, lithium with aluminium can be made in the same way. Concerning the application of this alloy in steel casting, see the abstract under Recent Metallurgical Patents.

Copper Refining.—F. L. Antisell, 875,641, Dec. 31, 1907. Application filed July 5, 1906.

The inventor proposes to separate the anodes and cathodes in an electrolytic copper refining cell by diaphragms. The object is to prevent any silver from being mechanically carried over from the anode to the cathode. Further, short circuits are prevented. While the diaphragm naturally increases the internal resistance, it is possible to counteract this by placing the anodes and cathodes closer together so that a greater output is obtained from a tank of given size. The diaphragm is made of a frame of vertical and horizontal wooden rods. The open rectangular space is being filled in or paneled with veneer of about 1/28 of an inch in thickness. White wood rotary-cut veneer forms a satisfactory material for the panels. The panels are preferably so constructed that the grain of the veneer runs vertically. The circulation of the electrolyte is maintained by feeding it into the tank at one end, circulating it through the tank and running it off at the other end.

Camphor.—C. Glaser, 875,062, Dec. 31, 1907. Application filed Jan. 26, 1906.

Isoborneol, borneol, camphene are oxidized to camphor by electrolyzing a 2½ to 5 per cent sodium chloride solution in a diaphragm cell, the isoborneol or other camphor-producing substance being placed on top of the electrolyte in the anode room. A current density of about 1 amp. per square centimeter of cathode is used. Heating accelerates the action. About forty parts of sodium chloride are sufficient for 100 parts isoborneol, but it is advantageous to employ an excess of sodium chloride. Since the latter is largely regenerated after the current is stopped, it is possible to produce large

quantities of camphor with a given quantity of sodium chloride.

Anode for Electric Cyanide Process.—R. J. Wisnom, 872,878, Dec. 3, 1907. Application filed Oct. 3, 1906.

The anode shown in Fig. 4 consists of a sack of canvas 1, with vertical lines of sewing 2 extending to within a short distance of the top, thus dividing the sack into a number of vertical pockets, connected at their tops to a horizontal transverse pocket. The pockets are packed tightly with lead peroxide in granular form. A conducting wire 3 is placed in the horizontal pocket, and the granular filling is pressed tightly in contact therewith by strips of wood 5 on each side of the pocket. Vertical strips 7 are fastened to one or both sides of the bag 1 to prevent it from sagging out of shape.

FIG. 4.—ANODE FOR CYANIDE PROCESS.

Mercury Cathode for Metal Deposition.—W. A. Hendryx, 866,859, Sept. 24, 1907. Application filed June 30, 1905.

This cathode is intended specially for depositing gold, silver and copper from their cyanide solutions, and is shown in Fig. 5 in vertical and horizontal cross-section.

A wooden frame 1 has a bottom 2 on which is placed a perforated plate 3 of cement or terra cotta. On this rests a filtering medium 4, like sheets of asbestos, and upon this the cathode 5 is placed, which consists either of mercury or of granulated lead and mercury or granulated zinc and mercury. Upon the cathode other sheets 6 of filtering material are placed, on which rests another perforated plate 6A.

like the perforated plate 3. By the clamping strips 7 the whole arrangement is held in position. This cathode is specially adapted for use in the inventor's cyanide process, the solutions percolating or filtering through the cathode envelope, and their metallic values being deposited on the mercury.

Electrolytic Production of White Lead.—F. W. Morris, 871,947, Nov. 26, 1907. Application filed Dec. 28, 1906.

As in the patent dealt with in the preceding abstract, an electrolytic cell of the Castner-Kellner-type is used, the two compartments being filled with sodium or potassium formate and connected at the bottom together by a body of mercury. Both the anode and cathode are made of lead. In the anode compartment lead formate and formic acid are formed and spongy lead and caustic soda or caustic potash in the cathode compartment. The current is then cut off and the spongy lead is shoveled from the cathode compartment into the anode

compartment, where it is dissolved by the remaining free formic acid and produces lead formate. The presence of the formic acid, which dissolves the lead but does not alter the mercury, prevents the amalgamation of the spongy lead with the mercury. The lead formate thus produced is siphoned out of the anode compartment into a tank, where it is associated with an alkali carbonate, such as ammonium carbonate, causing the precipitation of carbonate of lead, which settles to the bottom while the ammonium formate is drawn off as a valuable by-product. The carbonate of lead is substantially pure, "and will serve all the requirements for which the hydrate of carbonate or white lead of commerce is used"; but if hydrated carbonate is wanted ammonium hydrate is associated with the ammonium carbonate in the required proportion in the settling tank when a hydrated carbonate of lead is precipitated instead of a pure carbonate.

Tin Plating Iron Sheets.—H. L. Hollis, 827,063, Nov. 26, 1907. Application filed May 22, 1906.

The patent refers to mechanical details of supporting and conveying mechanism for use in electrolytic tin plating of iron sheets. A number of the plates to be treated is first stacked in a rack frame, and then a gripping frame, forming part of the conveying apparatus, is brought into position over the plates and clamping means brought into clamping engagement with the individual plates, whereupon the gripping rack with the supporting plates is raised by suitable tackle mechanism and conveyed on a trackway to a position above the electrolytic tank, whereupon the plates to be treated may be lowered in proper position with respect to the other plates in the tank. Supporting and guiding means are also provided on the gripping frame which engage about the plates to be treated to hold them in proper spacing when removed from the rack and when inserted into position between the other plates in the plating tank.

Cleansing Metal.—J. Hawthorne, 871,994, Nov. 26, 1907. Application filed March 26, 1907.

To clean gold and silver articles, they are placed in a tin or aluminium dish, filled with a comparatively weak but hot solution of soda ash, consisting of 97 per cent sodium carbonate, 0.75 sodium bicarbonate and 0.80 sodium chloride. The gold or silver article forms with the tin or aluminium dish a short-circuited galvanic cell, and any oxides or sulphides on the surface of the articles are reduced to metal by electrolytic action. The soda ash also acts on fat and grease which may be on the surface. Since the action is the reduction of the oxide or sulphide to metal no silver or gold is lost from the surface of the articles.

Ship Bottom Protector.—J. H. Schonberger and G. W. Frazier, 872,759, Dec. 3, 1907. Application filed Sept. 14, 1906.

The metal bottom of the vessel is unpainted, and is made the cathode in an electrolytic cell whereby the sea water is electrolyzed and hydrogen and sodium hydrate are set free on the cathode. This is claimed to protect it from the ordinary attacks of vegetable barnacles, mollusks or insect parasites.

BATTERIES.

Storage Battery.—T. A. Edison, 873,220, Dec. 10, 1907. Application filed Nov. 23, 1903. Assigned to the Edison Storage Battery Co.

In order to improve the output of his nickel-iron battery and to reduce the swelling of the active nickel mass in the nickel-plated perforated pockets in which it is maintained under pressure, a small proportion (15 per cent) of bismuth hydroxide is intimately mixed with nickel hydroxide and applied to the surfaces of flake graphite.

Storage Battery Grid.—J. Mark, 873,382 Dec. 10, 1907. Application filed Jan. 2, 1907.

The second claim refers to a grid "consisting of a frame provided with a series of spaced parallel and horizontally extending bars, and two sets of obliquely extending ribs on opposite sides of said bars, the said ribs of each set intersecting each other, and the said ribs being V-shaped in cross-section."

Storage Battery.—Q. Marino and F. W. Barton-Wright, 873,132, Dec. 10, 1907. Application filed Dec. 17, 1906.

What the inventors claim is: "In electric accumulators having the positive and negative plates supported horizontally and alternately one above the other, the combination therewith of separating boards of specially treated wood placed between the said plates and lines on each side with a layer of specially treated wood fibers, a hole or holes formed in each plate and board in line with each other, a raised rim forming the edge of each hole, so as to provide a continuous passage or tube running vertically through the said plates and boards, and a vertical screw-threaded rod fitted within and passing through each of the said passages or tubes for effecting the escape of the expanded gases."

Storage Battery.—H. Rodman and G. M. Howard, 875,213, Dec. 31, 1907. Application filed Dec. 22, 1905. Assigned to Electric Storage Battery Company.

Distinct advantages (a characteristic loose structure, uniform capacity, prolonged life) result from the incorporation with the active material or lead oxide of the negative pole plate of a storage battery of an inert finely divided material insoluble in the electrolyte. The material employed by the inventors is an insoluble sulphate, preferably sulphate of barium. This is precipitated from a cold solution of a soluble salt of barium by the use of sulphuric acid and is obtained in a state of exceedingly fine subdivision. It is mixed with the lead oxide in proportion of about 5 per cent by weight.

Battery Connection.—G. P. Blow, 873,600, Dec. 10, 1907. Application filed April 11, 1907.

The object is to do away with all screw connections and binding posts on dry cells. The inventor uses a zinc container, "a notch from the side of said container, a carbon element with a ball-shaped end, a connection passing through said notch and insulated from said container, resilient lips on said connection for embracing the ball-shaped end of said carbon element and a resilient member on said connection external to said container."

DISCHARGES THROUGH GASES.

Bleaching and Sterilizing.—S. Leatham, 854,508, May 21, 1907. Application filed July 10, 1904.

To bleach flour, sterilize milk, etc., the use of air is recommended, which is first passed through a silent discharge to change the oxygen into ozonic and then through a spark discharge to produce nitrogen oxides and probably other effects in addition. This method is more effective than either treatment alone or carrying on the two steps in the reverse direction.

MISCELLANEOUS

Electrotherapeutic Apparatus.—N. H. Raymond and J. C. Vetter, 872,148, Nov. 26, 1907. Application filed Aug. 24, 1905.

Details of construction of an apparatus consisting essentially of two parts, which are held in the two hands and are applied to such parts of the body which it is desired to treat electrically. One part contains a dry cell, the other part an induction coil and interrupter. The action is controlled by movements of the thumbs of each hand.

RECENT METALLURGICAL PATENTS

IRON AND STEEL.

Titanium-Nickel-Chrome Steel.—J. Churchward (867,642, Oct. 8, 1907) patents an alloy steel which is claimed to be particularly hard and tough and to have high tensile strength. It consists of 90.0 per cent by weight of steel (containing 0.5 per cent of carbon), 1.0 titanium, 0.5 chromium, 2.0 nickel and 0.5 manganese. The preparation of this steel offers a difficulty on account of the very high melting point of titanium, since it is important in mixing to prevent chilling. For this purpose manganese is said to be necessary. The titanium is melted in a crucible at a temperature believed to be about 3,000° C., and the steel, nickel and chromium are melted in another crucible and heated to a point just below the point of volatilization. The manganese is then added to the molten titanium, and while it is being melted and incorporated with the titanium, the molten nickel-chromium-steel alloy from the other crucible is brought into the crucible containing the titanium. The nickel is said to impart toughness, the chromium hardness and the titanium to increase both hardness and toughness.

Treating Blue Billy.—Blue billy is a by-product from the treatment of pyrites, and contains a high percentage of iron, and is comparatively low in impurities, notably in phosphorus, but it is difficult to handle on account of its refractory nature. J. G. Bergquest (877,394, Jan. 21, 1908, assigned to American Sintering Co.) proposes to mix blue billy and flue dust in about equal proportions together; the flue dust serves in the mixture to flux the blue billy and the blue billy serves to prevent adherence of the clinker to the furnace walls. The following comparative analyses of flue dust and blue billy show the approximate compositions of each; these analyses being each characteristic:

Flue Dust.	Blue Billy.
SiO ₂	8.00
Al ₂ O ₃	2.00
CaO	2.50
MgO	1.00
Fe	48.00
Coke dust.....	16.00
Sulphur	.27
	62 to 63 per cent.
	None.
	1.0 to 2.0 per cent.

It will be seen that the blue billy is composed almost entirely of oxide of iron, which in a pure state is practically infusible at all ordinary furnace temperatures, while on the other hand the flue dust contains considerable percentages of lime, silica and aluminium and a relatively large percentage of coke. The fusing point of the mixture is lowered to a degree well within the range of ordinary reducing furnaces. The inventor uses an inclined rotary furnace of the general type used in making Portland cement, the mixture of blue billy and flue dust being fed into one end and gaseous or pulverized fuel being blown into the other end.

Alloy for Iron and Steel Casting.—Bubbles and blow-holes in ingots of cast steel are chiefly due to the presence of three gases, oxide of carbon, hydrogen and nitrogen. By adding a small quantity of aluminium in the moment of casting the oxide of carbon is removed. The hydrogen and nitrogen may be removed by employing such metals as calcium, barium, strontium and lithium. It is preferable to employ these metals alloyed with aluminium so that all the gases are simultaneously removed. An alloy of aluminium and calcium, or of aluminium and barium, etc., may thus be employed. Concerning the method devised by M. Meslans (875,668, Dec. 31, 1907) for making such alloys, see abstract under Analysis of Current Electrochemical Patents.

THERMIT PROCESS.

Modifications of Aluminothermic Reaction.—Dr. Hans Goldschmidt's exceedingly useful aluminothermic method is essentially based on the high oxidation heat of aluminium. Extended researches have been carried out by the inventor, in recent years, to determine whether other elements with a high oxidation heat could be substituted for aluminium in his process. Calcium and silicon have been proposed and tried. As mentioned in his recent patent (875,345, Dec. 31, 1907) it has been more and more clearly borne out by these experiments that for technical reasons calcium alone is not suitable, while silicon alone or silicon mixed with aluminium had before been found to be unsuitable. These experiments have, however, established the fact that a calcium-silicon mixture or alloy or a calcium-aluminium mixture or alloy give high thermic effects. The use of an alloy has an advantage over the mixture in so far as it is more resistant against the atmosphere. The employment of a calcium-aluminium mixture renders possible the production of a thinly liquid slag, to which, by an addition of other substances, the property of "sintering" can be given, so that it becomes possible to use this mixture for all the known applications of the Goldschmidt thermit process. When mixing aluminium with iron oxide and bringing this mixture to reaction, the resulting molten iron is superheated to such a degree that a quantity of iron equaling about one-third the total weight of the mixture may be added, and still the iron, as well as the slag, will be perfectly liquid. If a mixture is prepared of calcium, with an equivalent quantity of iron oxide, and again metallic iron to the amount of one-third of the weight of the mixture is added, a "sintering" mass is obtained, partly on account of the production of a slag which fuses with difficulty. If, however, a mixture is made of aluminium and calcium, intimately mixed with iron oxide or iron-oxideprotoxide, in the manner of the Goldschmidt thermic process, the thermic effect is considerably increased, and iron weighing two-thirds of the total weight of the mixture can be added without causing the slag to solidify or the iron to become sluggish. The

greatest efficiency and the quietest reactions are generally obtained with mixtures composed in such a way as to give "the most possibly thinly liquid slag": a thinly liquid aluminate is calcium-aluminium-oxide ($3\text{CaO} \cdot \text{Al}_2\text{O}_3$). This is actually obtained by mixing together about 60 per cent of an equivalent mixture of aluminium with iron oxide or oxydulated iron, respectively (so-called "thermit"), and 40 per cent of an equivalent mixture of finely divided calcium and iron oxide; this nearly exactly corresponds with an alloy of equal parts of calcium and aluminium (to be exact, 49 Al:51 Ca). As regards calcium-aluminium-silicium-thermit a good result and a highly thinly liquid slag are yielded by a mixture of metals, which, after the reaction, leaves a slag of the following composition: Calcium-aluminium-silicon-oxide ($3\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{Si}_2\text{O}_3$), and which accordingly would have to consist of 50 parts aluminium-thermit, 70 parts calcium thermit and 100 parts silicon thermit. Still the caloric effect is lower than that of the old aluminium-thermit (about 75 per cent), but the mixture is still suitable for technical purposes, especially for welding. Concerning

further details, reference must be had to the patent, which contains a great deal of information concerning the behavior of various mixtures of alloys.

COPPER.

Converting Copper Matte into Blister Copper.—J. D. Burgess, of Tucson, Ariz. (877,292, Jan. 21, 1908), wants to substitute the apparatus shown in Fig. 1 for the "ponderous" converters now used in bessemerizing copper matte. The copper matte is taken from the matting furnace V in molten condition and is carried through a series of three inclined boxes B, B', B². Each steel box is 15 feet in length, 2 feet square on the outside and lined with firebrick, leaving an inner circular or oval opening extending from end to end. Tuyeres extend into the sides of the box, being disposed at an angle pointing downwardly and toward the discharge end of the box. In all boxes compressed air is supplied through the tuyeres. In the first box the reaction is $2\text{FeS} + 3\text{O}_2 = 2\text{FeO} + 2\text{SiO}_2$, and the air blast also accelerates the flow of the liquid matte through the box. The desulphurized matte is discharged from the first box B into the second Box B', and simultaneously silica is introduced from the hopper P through the open-top spout Q, while the hood U carries away the gases evolved during the conversion of the matte. In the second box, through introduction of the silica and through admission of compressed air through the tuyeres, the reaction $\text{FeO} +$

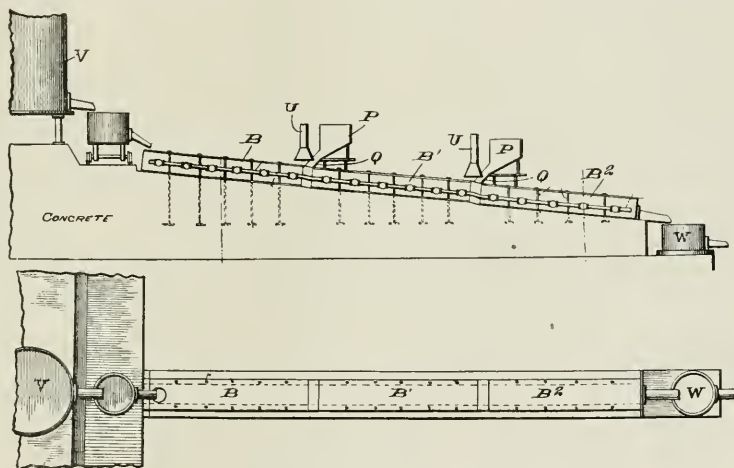


FIG. 1.—CONVERTING COPPER MATTE INTO BLISTER COPPER.

$\text{SiO}_2 = \text{FeSiO}_3$ is produced. The mass then flows into the third box B' and through the hopper P simultaneously; finally comminuted limestone mixed with coke dust is fed into the mass. This addition gives greater fluidity to the silicious iron slag, separated from the pure copper in the second box, and the coke dust develops and restores heat lost during the operation. At the end of the third box the blister copper flows by gravity into a receptacle. The slag floats on the top and is skimmed off.

ZINC AND LEAD.

Zinc Oxide.—A patent of H. Pape (877,114, Jan. 21, 1908) describes a method of obtaining oxide fumes from ores and furnace products. The inventor remarks that the well-known Wetherill method of making zinc oxide is useful for certain ores, particularly American franklinite. But if the ore sinters or shows a tendency to melt, this method "cannot be employed, as much too great quantities of zinc are then left behind in the residue." The method described by him is said

to be applicable to every kind of zinc ore or zinkiferous products. The yield is claimed to be so good that, for example, zinkiferous materials may have the zinc removed from them up to 3 per cent or less. The ore or furnace product is disintegrated and intimately mixed with carbon. The ore should be reduced to such granular size that at least 50 per cent of the materials are less than $\frac{1}{32}$ millimeter ($\frac{1}{32}$ inch) in diameter. These grains are mixed with carbons in such a manner "that on an average every particle of ore is separated from its neighbor by at least one particle of carbon." The amount of carbon must be sufficient, not only to reduce and vaporize the metal, but also for melting the slag which is formed. After the zinc ore has been mixed with carbon, and such additions as may be necessary, like lime and sand, an agglutinant (cement or disintegrated coal-tar pitch) is added if the mixture in itself is not in a condition to become sufficiently hard after it has been pressed together. The mass is then molded into briquets, either by means of a press or in a suitable sintering furnace. The briquets are fed from above into a furnace, while a powerful current of air is passed through the charge by means of a blast, or by suction, and is regulated in such a manner that the charge is heated to at least a red glow up to its upper surface. The products which are newly thrown on to the charge catch fire and glow on the upper surface, and the metallic vapors which rise up from the lower part of the charge burn to oxides at the upper surface of the charge. Air is preferably admitted in the melting zone, in which there must be incandescence when working up zinc ores, and a quantity of coke in pieces or lumps is added to the charge, so that the necessary temperature is certainly maintained in the melting zone. When the briquets arrive in the melting zone in an already semi-plastic state, the zinc compounds which are in the briquets in direct contact with carbon are decomposed, and the zinc vapors which form, burn to zinc oxide again above the melting zone. At the high final temperature, which characterizes this process, a sintering together of the grains of ore from which the zinc is removed is prevented from taking place, and the same always become molten. By the separate melted grains flowing together, dross is finally formed, which is blown out from the lower part of the furnace in the usual manner. The heat of the gases of combustion which carry away the volatile metallic oxides which are formed in the furnace may be employed in suitable manner: for example, for drying ores, or for heating steam boilers. Other metals which are reduced, but do not vaporize, pass into the slag.

TIN.

Detinning with Chlorine.—Three patents of Elmer A. Sperry (872,092, Nov. 26; 873,699, Dec. 10, and 875,632, Dec. 31) refer to this process, which at present attracts so much attention. The necessity of using absolutely dry chlorine and the difficulties of getting and maintaining it in this condition are pointed out, and it is stated that these difficulties may be overcome by treating the ordinary commercial chlorine with anhydrous stannic chloride. Commercial chlorine contains usually air, carbon dioxide and moisture. This gas mixture is at first chilled or refrigerated to throw out as much as possible the moisture and is then treated with anhydrous stannic chloride. The anhydrous stannic chloride stands ready to take up any moisture or water which may be present or which later may be introduced. The stannic chloride hydrate is an active agent in detinning as it takes up tin to form stannous chloride, which quickly is transformed to stannic chloride through the action of the chlorine present. The iron scrap thus obtained should undergo further treatment, especially if it is to be stored. Though the scrap may be comparatively dry, still there is a tendency to the presence of ferric chloride, either in the form of spots, specks, powder or a coat on the surface. This material is hygroscopic even to the point of deliquescence, and the water attacks the iron, breaking up into

the oxyhydrate, etc. The treatment of the iron scrap, which Mr. Sperry proposes, is first washing the iron with water under agitation. "The treatment is then concluded by throwing the scrap into the alkaline reaction or coating same by any suitable material; for instance, silicate of soda or by a solution of sodium hydrate."

ALLOYS.

Anti-Friction Bearing Metal.—M. C. J. Reed, of Philadelphia (874,866, Dec. 24, 1907), has obtained an alloy of 85 per cent lead, 10 per cent arsenic and 1 to 5 per cent copper, which is stated to give good results as an anti-friction bearing metal. For bearings for certain uses the proportion of arsenic may be very much greater and may in some cases advantageously be increased to 50 or even 70 per cent. In preparing the alloy, particularly where the proportion of arsenic is relatively high, it is advantageous to melt the elements together in a receptacle while under greater than atmospheric pressure so as to prevent volatilization. For anti-friction bearings the copper may in some cases be dispensed with and the arsenic and lead be combined by melting.

SYNOPSIS OF PERIODICAL LITERATURE

SPECIFIC HEATS.

Carbon Dioxide, Steam and Nitrogen.—Prof. L. Holborn and F. Henning have determined at the German Reichsanstalt the specific heats of nitrogen, carbon dioxide and steam up to 1440°C . The full account is given in *Annalen der Physik*, Vol. XXIII, p. 811; an abstract in *London Engineering*, Jan. 3. The mean specific heats c_m between the temperatures O and t degrees C for nitrogen and carbon dioxide and the mean specific heat of water vapor between temperature 110 and t degrees C, are given by the following formulas. The results for steam may be fairly well expressed by two formulas; the one a quadratic formula, would yield a minimum at 190° , which the other exponential formula does not indicate:

Nitrogen—

$$c_m = 0.2350 + 0.000019t.$$

Carbon dioxide—

$$c_m = 0.2010 + 0.0000742t - 0.00000018t^2.$$

Water vapor—

$$(1) \quad c_m = 0.4660 - 0.0000168t + 0.000000044t^2.$$

$$(2) \quad c_m = 0.4544 + 0.006925 \times 10^{0.0001212t}.$$

The observed values for steam differ from those calculated by these two formulas in no instance by more than 1.1 per cent. In the following table the final values are given of calculated mean specific heats c_m and the calculated true specific heats c_w . The c_m for water vapor refer to formula (2). The values c_m are mean values of specific heat between O° (or 110°) and t° , as explained above. The values c_w are the actual values of the specific heat at the temperature t .

t DEG. CENT.	NITROGEN		CARBON DIOXIDE.		WATER VAPOR.	
	C_m .	C_w .	C_m .	C_w .	C_m .	C_w .
[0]	0.2350	0.235	0.2010	0.201	0.4613	0.460
200	0.2388	0.243	0.2151	0.229	0.4642	0.465
400	0.2426	0.250	0.2278	0.250	0.4682	0.475
600	0.2464	0.258	0.2390	0.271	0.4740	0.491
800	0.2502	0.265	0.2491	0.285	0.4820	0.515
1000	0.2540	0.273	0.2592	0.295	0.4935	0.554
1200	0.2578	0.281	0.2641	0.301	0.5090	0.614
1400	0.2616	0.288	0.2696	0.303	0.5323	0.707
[1600]	0.2654	0.296	0.2736	0.300	0.5646	0.849

The values for [O] and [1,600] deg. Cent. are extrapolated.

IRON AND STEEL.

Reduction of Iron Oxides.—Schenk, Semiller and Falcke, in the *Berichte der Deutschen Chemischen Gesellschaft*, 1907, p. 1704 (*Stahl und Eisen*, Sept 4), have investigated experimentally the equilibrium between CO, CO₂, Fe, FeO and carbon. Their results are as follows:

I.

System: Fe, FeO, C (amorphous), CO, CO₂.

Temperature, °C....	550	596	651
Pressure, m.m.....	137	296	571
Gas, per cent CO....	53.7	55.5	57.9
per cent CO ₂	46.3	44.5	42.1

II.

System: Fe, FeO, C (graphite), CO, CO₂.

Equilibrium was much more slowly reached, taking at 650° C. three days.

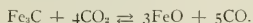
Temperature, °C....	660	700	...
Pressure, m.m.....	129	360	...
Gas, per cent CO....	59.6	60.4	...
per cent CO ₂	40.4	39.6	...

III.

System: Fe₃C (cementite), FeO, C (amorphous), CO, CO₂.

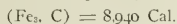
Temperature, °C....	672	722	774
Pressure, m.m.....	131	298	562
Gas, per cent CO....	86	87.5	89.5
per cent CO ₂	14	12.5	10.5

From this latter result it follows that cementite is much more easily oxidized than metallic iron. The equilibrium reaction is:



These considerations make it appear probable that a gas containing at least 96 per cent of CO is necessary in order to form cementite and thus to carburize metallic iron; but iron oxide, on the contrary, can be converted into cementite with lower proportions of CO.

From the course of the reaction the authors calculate the heat of formation of Fe₃C at 650° to 700° as



Thermit Process in Iron and Steel Metallurgy.—Two recent publications discuss two different and important applications of thermit in iron and steel metallurgy. In a Franklin Institute paper (*Journal of the Franklin Institute*, July 1907, recently reprinted by Goldschmidt Thermit Company) A. Obholzer reports on the methods used to avoid piping in heavy ingots in the Hungarian Government steel foundries at Diosgyur. For the principle of this process see our Vol. I, p. 533. It has been found by actual experience in the foundries named, that when sinkheads are employed and a charge of thermit is introduced, by fastening a box filled with thermit tightly to an iron rod and sinking it into the fluid steel, the steel begins to boil up strongly and slag is brought to the surface plentifully. The slag is taken off and more fluid steel is poured in. The heat developed by the thermit reaction causes the steel to remain liquid so that the piping can be filled up from the feeding head. The author points out the advantages of pouring heavy ingots with feeding heads, and states that by this application of thermit they have succeeded to remove piping to a very important extent. The possibilities of the thermit welding process for quick repairs on heavy ordnance are discussed in the *Journal of the United States Artillery*, September and October. It is pointed out that thermit makes possible the carrying out of important repairs on gun carriages and other ordnance in the field. In many cases it may be the means of placing guns in commission which would otherwise be useless, or at least require treatment in a repair shop, before being rendered fit for service. In the Russo-Japanese war, thermit has played an important part in making speedy repairs of warships, particularly on the

Port Arthur fleet. General rules are given on making thermit welds and the applications to gun cradle and ship repair are described and illustrated.

Removal of Sulphur in Electric Induction Furnace.—In *Stahl und Eisen* of Nov. 6, A. Schmid discusses the rationale of the removal of sulphur from steel in the electric induction furnace. He does not deny that on account of the high temperature, which can be produced in the electric furnace, highly basic slags remain fluid and have an increased effect. But he thinks that this is not the complete explanation. He offers the hypothesis that there is a specific effect of the electric alternating current itself, which causes the desulphurization under simultaneous action of oxide ores. The use of oxide ore seems important, as is shown from results obtained by the author at Gurtellen. The results are given of various furnace runs, in which the author found that the sulphur in the steel bath was greatly reduced, while the slag remained free from, or low in sulphur. What then has become of the sulphur? The author thinks that the sulphur is oxidized by the oxide ore and escapes as sulphur dioxide into the air. He thinks that this is a specific effect of alternating currents and would not take place with direct current, but no proof of this is given.

GOLD AND SILVER.

Cyanide Process.—In the November issue of the *Western Chemist and Metallurgist* Dr. F. W. Traphagen gives a review of the development of the cyanide process and its present condition. A number of interesting early patents are first analyzed, and the present status is then summed up as follows: In the practical application of the process the percolation method should always be used when results justify it. This method is so simple, so easily carried out, and so cheap, that where satisfactory extraction can be obtained by its use it is to be adopted. Unfortunately, however, because of inability to percolate material as received, or of the necessity for grinding in order to make a satisfactory saving, agitation, or preferably, a combination of agitation of slimes and percolation of sands after hydraulic classification into these two products, becomes necessary. Of course, with the various devices for separating solution and slime, the problem of slime treatment is much simpler than in the earlier days of the process, and so much better results are obtainable after finer grinding than, notwithstanding the greater difficulties in handling, the agitation treatment is rapidly extending. As to the selection of a machine for fine grinding, the author thinks that the tube mill fulfills the conditions far more perfectly than any other device. As to slime filters, he thinks that the fault for the present situation should be placed in the United States patent office; in granting a patent, there should be sufficient proof that there was no infringement by it on existing patents. At the present time the treatment of telluride ores seems to have found successful solution in the roasting-cyanidation method, and shortly before the fire which destroyed the Dorcas mill, results were being obtained that left little to be desired. The use of the electric current as an aid to solution of gold and silver has not yet met with marked success in ore treatment, but there are good reasons for believing that with many ores greatly improved extraction could be obtained. In like manner the many suggested oxidizing agents have never been extensively adopted, and when oxygen is needed as an aid to extraction, it is usually added by some method of aeration. Precipitation of values simultaneously with extraction and in the same vessel has also failed of general adoption, mainly because of mechanical difficulties. The most important problem before the metallurgist for solution is now that involved in the treatment of silver ores, for while high percentages of gold may be extracted with little difficulty, silver, on the other hand, with few exceptions, yields very imperfectly to cyanide treatment, the average extraction being somewhere about 50 per cent.

A Modern Method of Lead Burning.

By CECIL LIGHTFOOT, CONSULTING ENGINEER.

The use of pure oxygen in place of air not only enables much more perfect combustion and higher temperatures to be obtained than are possible with the hydrogen and air system, but it possesses a still further economic advantage in that either coal or natural gas from the town supply may be employed instead of hydrogen.

The oxy-coal gas blowpipe is constructed on the injector principle, and is now extensively used by lead burners. By its use oxygen delivered under slight pressure from a trade cylinder is caused to draw the gas direct from the ordinary town supply and then eject the mixed gases in the right proportion through the nozzle of the blowpipe. The system is being introduced by The Linde Air Products Co., of Buffalo, and its superiority over the old hydrogen and air system, as regards quality of work, economy and convenience in use is admitted by all who have adopted it. It is suitable for ordinary flat work, horizontal and upright joints, overhead patching and the jointing of ordinary lead piping. Any workman conversant with the hydrogen and air system of lead burning will experience no difficulty in operating the oxy-coal gas blowpipe.

It is estimated that in regard to the question of economy there is a saving of approximately 50 per cent by using the oxy-coal gas system in preference to the old hydrogen-air method of lead burning. There are besides many other advantages, as enumerated here below:

1. The hydrogen generator is dispensed with.
2. The air bellows or pump is dispensed with, and consequently the services of a boy are not required.
3. Instead of having to move a heavy hydrogen generator and bellows from one job to another, it is generally only necessary to move a light cylinder containing the oxygen required.
4. No apparatus to get out of order, involving expenditure, delays and repairs.
5. As neither zinc nor sulphuric acid is used, there is no deleterious matter to be carried through the blowpipe to act injuriously on the lead seam.
6. No preheater or "Fou-Fou" is required on heavy work. The oxy-coal gas flame is so hot that even heavy lead in wet and cold positions can be burned "in situ" without preheating.
7. No gas is generated when the blowpipe is not in use, and consequently there is no waste of gas and no charge to withdraw overnight.

It may be stated that for cases where a supply of town's gas is not available coal gas can also be obtained in cylinders, or the oxygen may be used advantageously with the hydrogen "machine."

Two New Pyrometers and the Application of the Radiation Pyrometer for Determining the Temperature of Molten Iron and Copper.

The two portable pyrometers described in the following article have been devised and are manufactured by Dr. C. B. Thwing, of Philadelphia, Pa. The instrument shown at the top of Fig. 1 is of the LeChatelier thermoelectric type, while the second instrument shown at the bottom of Fig. 1 is a radiation pyrometer, measuring the total radiation like the Fery pyrometer. Perhaps the most interesting feature of the galvanometer is the very complete temperature compensation, which does not introduce any dead resistance into the circuit, so that the galvanometer may be made highly sensitive without requiring any leveling. This contributing to the convenience and portability of the instrument, the weight of which is only 3 pounds.

It is important to correct for a change of resistance of the

galvanometer coil, due to temperature changes. With a rise of temperature of 50° F., the resistance of copper increases more than 10 per cent. In order to produce, nevertheless, at all temperatures equal deflections by equal e. m. f.s, the following principle is applied in the Thwing instrument. The deflection of the coil in a magnetic field is proportional both to the current passing through the coil and to the magnetic



FIG. 1.—TWO NEW PYROMETERS.

flux. The latter depends essentially on the reluctance of the air-gap and the fundamental idea of the compensation is to automatically decrease the length of the air-gap when the temperature rises, so that any increase of the electric resistance of the copper is just counterbalanced by a decrease of the magnetic reluctance.

Fig. 2 shows the arrangement of the electric and magnetic circuits. The coil rotates about one of its ends in a uniform field between two plane pole pieces. The two magnet arms which are connected in parallel by these pole pieces are

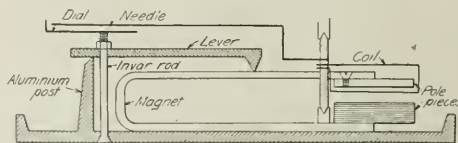


FIG. 2.—COMPENSATION ARRANGEMENT.

very thin and quite flexible. They are pressed together somewhat by the long end of a lever, while the short end rests upon a post which is part of the aluminium case. Near the bearing of the lever on the post and at the proper distance from it, the lever is pierced by a light rod of invar metal, which serves to apply pressure to the magnet. If the temperature of the air rises, the aluminium post expands much more than the invar rod, thus forcing the long end of the lever downward and diminishing the gap between the poles of the magnet by an amount which may be made accurately to compensate for the corresponding increase of the electric resistance in the coil. Different materials are in use for the thermocouples and ac-

cording to Dr. Thwing it is perfectly practicable to dispense with the use of platinum for all ordinary purposes.

The second instrument is, as mentioned before, a radiation pyrometer and consists of a receiving tube and a portable galvanometer. The receiving tube is of light steel oxidized to blackness on its inner surface and is 90 cm. long and 25 mm. in diameter. At the front, or receiving end, a diaphragm determines the angular aperture in conjunction with a conical mirror placed about 70 cm. distant, near the other end of the tube, which is held in the hand when the tube is pointed at the surface whose temperature is to be measured. The radiations are received near the apex of the mirror upon a thin couple of iron constantan, which reaches a state of thermal equilibrium in about 2 seconds after exposure to the radiations. Since all radiations reaching the mirror are transmitted by multiple reflection to the surface of the couple regardless of their direction, the instrument is in focus for all distances. The angular aperture being constant, the indications are independent of the distance of the object so long as the surface is larger than is required to fill the angle.

The galvanometer is pivoted and does not require leveling, thus making rapid work possible in situations where the time required for setting up and focusing a telescope and leveling the galvanometer would be a decided hindrance. The instrument is compensated for temperature variations in the resistance of the moving coil by an automatic variation of the magnetic reluctance as described above in connection with the thermoelectric instrument. This arrangement makes unnecessary the introduction of a dead resistance for swamping the variations due to temperature and permits good control of the needle by the control spring with a fairly high sensibility. Three millivolts is sufficient to produce a full scale deflection of 60°. It is calibrated according to the well-known Stefan-Boltzmann law for total radiation.

This instrument will not measure the temperature of a flame, since the flame is partly transparent and the indication obtained would be almost wholly due to the body beyond the flame. If there are, therefore, hot air or flaming gases between the instrument and the opaque hot body, the temperature of which is to be measured, they will not produce any important change in the readings. Smoky flames will, of course, cut off a part of the radiation and cause the pyrometer to read too low. A light mica window prevents air currents from entering the tube, so that hot or cold currents outside produce no effect on the readings of the instrument. The galvanometer may be quickly placed upon the floor, or a convenient box, as it does not require leveling. Two minutes is ample time to place the instrument and take the temperature of a pot of metal. No focusing is necessary and it is sufficient to simply point the pyrometer towards the body, the temperature of which is to be measured.

The temperature of the contents of a large annealing furnace or of a brick or porcelain kiln is quickly taken by pointing the receiving tube through a peephole at the portion the temperature of which is to be measured. As the tube is less than an inch in diameter a very small hole will suffice. A recorder is attached when desired.

Extended experiments have been made by Dr. Thwing in connection with the measurement of the temperature of molten iron and copper, and some very interesting results were obtained, an account of which was given by Dr. Thwing in a paper recently read before the American Physical Society. From numerous experiments made by him and others to measure the temperature of molten iron by means of the radiation pyrometer it became evident that the results were always obviously much too low. The readings obtained by pointing the telescope at the flowing iron were considerably less than that of the same iron as it solidified in the ladle. This necessitated the conclusion that the emissivity of clean, molten iron is much less than that of a "black body," which solid iron ap-

proaches quite closely, and to which the Stefan-Boltzmann law refers.

Dr. Thwing made a series of experiments to determine, at least roughly, the constant of radiation for iron and copper, since the importance of a knowledge of the temperature of these metals in various industrial operations is coming to be recognized by metallurgists to have considerable importance, and the principle of total radiation offers an extremely convenient means of making such measurements.

Comparative measurements were made with the Thwing radiation pyrometer and with LeChatelier pyrometers, the couples of which were enclosed in quartz tubes, and in some cases further protected by iron or graphite tubes. The short life of the couples precluded the making of a large number of observations by their means.

At an iron foundry the iron was drawn continuously from the cupola into a large mixing ladle, whence it flowed, under a dam into the pouring ladles. The receiving tube was pointed alternately at the stream flowing into and out of the mixing ladle, while the LeChatelier couple was immersed in the ladle, the temperature measured by the couple being considered the same as the average temperature of the two streams. The fall of temperature in the ladle was about 40°.

At a Bessemer plant the LeChatelier couple was inserted in the 15-ton pouring ladle and the radiation measured from the stream as it issued from the bottom of the ladle. The stream was here certainly free from all slag and oxide. A similar condition was quite fully realized at the iron foundry by pointing at the lower or back side of the stream.

The results are summed up as follows. For cast iron at 1,300° to 1,400° C., the intensity of total radiation from the molten metal was found to be 0.20, and for mild steel at 1,600° to 1,650° C. 0.28 that of the radiation from solid metal at the same temperatures.

Observations made upon open-hearth furnaces within the furnace, where black body conditions obtain, and at the stream as it issues from the furnace, indicate that the value found holds for temperatures up to 1,800°, and there is no evident reason why it should not hold for still higher temperatures.

A smaller number of observations made upon copper gave a value for the emissivity of that metal in the molten state of but half that of iron, or 0.14 that of a black body. The low emissivity of molten copper has been remarked by workmen, who find that molten copper in the ladle burns the face much less than the same copper when cooling in large ingots where the exposed surface is about the same as in the ladle.

Large numbers of measurements of molten iron give concordant results and point to a constancy of the constant for molten metal sufficient to permit of the employment of the same pyrometers as are used for solid metals by the use of a factor or by employing two scales.

A New Heat Gauge or Electric Pyrometer.

The accompanying illustration shows a new heat gauge or electric pyrometer which is a reliable and substantial instrument for shop use. This device is the outcome of some years spent in research work on alloys having a high melting point and giving at the same time an electromotive force sufficiently high to produce a thermocouple that can be used with a more robust portable millivoltmeter instead of the usual delicate galvanometer. The outcome has been a reliable heat gauge for measuring the usual industrial furnace temperatures at a cost that will enable the smallest shop to avail themselves of this great aid to accuracy.

On account of the large diameter of the wires and the metals of which it is made this thermocouple or "hot end" needs no protecting tube, thus doing away with use of expensive and fragile porcelain tubes. At the same time the temperature of

the hot end is then exactly the same as the temperature of the molten metal to be measured. This is especially important in taking the temperature of molten aluminium, which must be poured at as low a heat as is possible.

The Hoskins thermocouple responds quickly and indicates



PYROMETER.

without lag the temperature of the material measured. It is not affected by furnace gases and does not alloy with the non-ferrous metals, such as aluminium and its alloys, brass, zinc, copper, lead, etc. These valuable properties make it safe for use in the foundry, and will enable the foundries to repeat with certainty the pouring temperatures that have been found to be

work and saves many times its cost in a very short time.

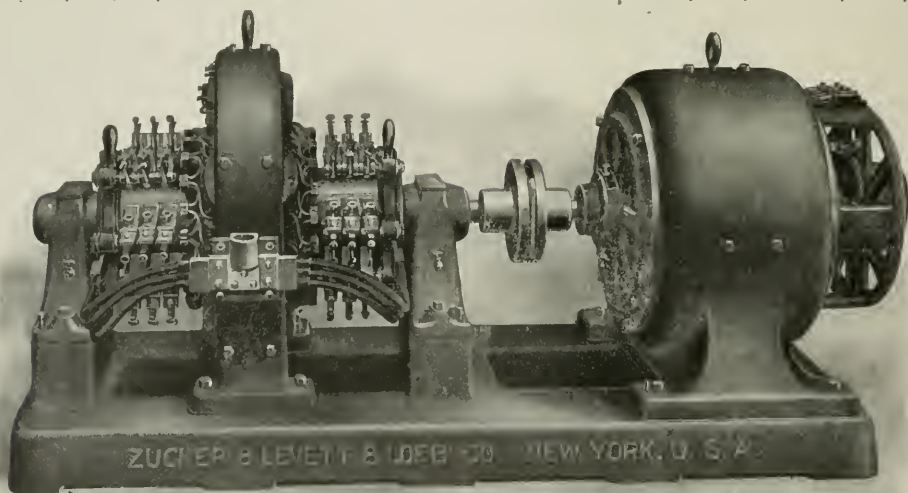
This is well illustrated by the experience of a prominent automobile manufacturer, who states that before he had a heat gauge he employed the highest paid man in his shop to do the hardening. Now he gets better results with the lowest paid man in the shop, who is told to keep his furnace at 750° C., or such other temperature as the work demands.

The Hoskins thermocouple has more than four times the electromotive force of the platinum-rhodium couple, giving 40 millivolts at 1,000° C., as against 9 millivolts for the platinum-rhodium couple.

Bureau of Standards tests show a breakdown point at 1,450° C., and it is guaranteed accurate and durable up to 1,200° C., but may be used occasionally at as high temperatures as 1,400° C. or 2,550° F. Special scales are made for intermediate temperatures. The standard instruments are furnished with the Fahrenheit or Centigrade scales, reading from 400° F. to 2,550° F., or 200° C. to 1,400° C. The Hoskins Co., 93 Erie Street, Chicago, will gladly send a catalogue showing the Bureau of Standards tests with complete information.

Multiple-Voltage Dynamo for Electroplaters.

The adjoining illustration shows a multiple-voltage electroplating dynamo built by Zucker & Levett & Loeb Co., of New York City. As shown in the illustration, this machine has two commutators and two sets of brushes, one on each side of the machine. The two commutators are connected each with one-half of a double winding on the armature. Each set of brushes may be connected to one plating tank, so that two different tanks may be operated from the same machine at the same time, and both may be operated independently of



ELECTROPLATING DYNAMO.

best for strength and to make sound castings. In the machine shop it is usual for each tool maker to harden his own work, and because he is called on to do this only when each job is finished he has to depend on his judgment for the proper temperature and try and remember about how hot he heated the last job. The use of a heat gauge eliminates all this guess

each other, since by placing a rheostat in each circuit it is possible to adjust the voltage impressed at the terminals of each tank at will, independently of the voltage impressed on the other tank. It is further possible by connecting the negative brush on one side of the machine with the positive brush on the other side of the machine, to connect the two armature

windings in series, so that at the two free brushes the double voltage is now obtained.

If the machine is built, for instance, to give on each side 5 volts normally, it is possible to supply any voltage between zero and 5 to two tanks simultaneously and independently with the aid of two rheostats. Or by connecting the two voltages in series it is possible to obtain anything between 5 and 10 volts. The savings in floor space and first cost obtainable by this single machine are quite evident.

All these changes are very easily made by means of only three switches. One switch serves for connecting the two windings of the dynamo in series. When this switch is open there is no connection between the two windings, and current is taken off from the two sides of the machine independently of each other and fed to two local circuits. One switch in each of these two local circuits permits to open and close them at will while two rheostats in the same two circuits permit regulating the voltage at will.

The illustration shows this dynamo direct connected to a motor. It is, however, also supplied by the Zucker & Levett & Loeb Co. without the motor, so that they may be driven by belting, etc. These generators are built in capacities from 400 to 10,000 amps.

Portable Heaters for Oil Fuel.

In many cases, work to be heated is too bulky to be brought to the furnace, or for other reasons this is inconvenient or impossible. In such cases it is necessary to bring the heating apparatus to the work. The portable heaters for oil fuel made by the Rockwell Engineering Co., of New York City, prove to be of greatest convenience and usefulness for such purposes, being exceedingly simple to operate. They are made in two types.



SKIN-DRYING WITH OIL HEATER.

The first type is self-contained and must be operated with kerosene or coal oil. In this type the oil is vaporized. The oil consumption is about 2 gallons per hour. The tank containing the oil is provided with a hand-pump, which is used not only for charging the tank with oil but also for obtaining the air pressure (25 pounds). As the air expands only in proportion to the amount of oil consumed it requires little attention. Two hoses with two burners may be fitted to one tank when it is advisable to heat both sides of a heavy object at the same time.

The second type burns crude as well as refined oil, but can be used only where compressed air is available, which is required to atomize the oil. The oil consumption is from

1 to 3 gallons per hour, according to the temperature desired. The size of the flame and the temperature may be changed instantly to suit various requirements by regulating the supply of air and oil. Fifty pounds of air pressure or more will give the best results for high temperatures such as used in brazing, while 10 to 20 pounds of air pressure is ample for skin-drying molds, where a soft, sweeping flame is desirable.

The adjoining illustration shows the application of the Rockwell heater to skin-drying molds, but it is evident that these heaters may be applied for manifold purposes, such as annealing, hardening, expanding, bending, brazing, etc., and should prove useful in boiler shops, shipyards, railroad shops, foundries, etc. Water departments use these heaters for melting lead out of pipe joints.

Notes.

Thermit vs. Weldite.—With reference to the late action of Thermit Limited in London against Weldite Limited for infringement of the former's patent rights for the production of pure metals and for welding metals by the well-known thermit process in which Mr. Justice Harrington, in April last, gave judgment in favor of Thermit Limited, we learn that on Saturday, Dec. 21, an order was made by Mr. Justice Parker, in London, on the petition of Thermit Limited for the revocation of (British) patent No. 10,881 of 1905, granted to Claude Vautin for the process the use of which by Weldite Limited formed the subject of the above action.

Lehigh Valley Section American Chemical Society.—The annual meeting of this section was held on Friday, Jan. 24. Mr. George P. Adamson, of Easton, Pa., reported on the annual meeting of the Society at Chicago. Dr. J. W. Richards, of Lehigh University, spoke on the vapor tension of metals and other substances. Mr. R. K. Meade discussed the systematic keeping of laboratory records. There were twenty-two members present.

Water Power Development in New England.—The development of the Connecticut River Power Co., which has been noticed before in these columns, is now well under way and the company expects to have 10,000 kw. for sale within twelve months. The location of this power, which is in Central New England, makes this development one of considerable importance and value to prospective electrochemical plants, especially as there should be a good demand for certain electrochemical products from various New England industries.

Electric Zinc Reduction in Canada.—In a recent consular report we find the following note from a Canadian newspaper: "The Canadian Zinc Co. is making good progress with the completion of its plant, which should be finished and in operation by the beginning of next February. The plant is designed for electric reduction of zinc, the first of its kind on the continent, although a similar plant is working successfully in Sweden. At the present time much of the lead ore of the Slocan occurs with zinc, and a penalty is demanded by the smelters for zinc units when over 10 per cent. This frequently means that the lead mine cannot be operated because of the zinc penalty and because no values are obtainable for the zinc. The establishment of the Canada Zinc Works in Nelson means the opening up of many idle Slocan properties." Although not stated in this report, it is well known that this plant is the outcome of the endeavors of Mr. Fred T. Snyder. We published a recent paper by Mr. Snyder on electric zinc smelting on page 489 of our Vol. V., and abstracted his patents in our Vol. IV., pp. 152, 319, 503 and in our Vol. V., p. 323.

Calendars.—We acknowledge with pleasure the receipt of a number of pretty calendars. Two different ones were received from the Roessler & Hasslacher Chemical Co.; one is a reproduction of a picture of a fantastic young lady by

Winnenberg, while the other, with reference to the ferro-alloys handled by this company, is fittingly illustrated by a scene from Schiller's famous poem on the walk to the iron foundry. The pretty girl with a mask on last year's calendar of the National Carbon Co. has changed on the new calendar into a ripe beauty from the brush of Ph. Boileau. The New York Brick & Paving Co. reproduce J. G. Brown's "Attention," a charming picture of a loutblack-boy with his little fox terrier dog. C. W. Levitt & Co. have selected a picture from rural life by F. C. Ransom, illustrating a line fence dispute between two stubborn farmers, while the calendar of the Kny-Scheerer Co. bears their well-known picture of an alchemist in his laboratory.

The business of the late Dr. Peter T. Austen, who died on Dec. 30 after a long illness, will be continued by Mr. Frederick J. Maywald, who has been associated with Dr. Austen and in charge of his laboratories for the past fourteen years. Mr. Maywald is familiar with Dr. Austen's methods, and has had a widely varied experience in all lines of chemical work, all the cases which Dr. Austen undertook having passed through his hands. The offices and laboratories will be located as heretofore at 89 Pine Street, New York City.

Messrs. Byrnes & Townsend, patent lawyers, 918 F. Street, N. W., Washington, D. C., announce that they have associated with them Mr. John H. Brickenstein, former examiner in metallurgy and electricity and late senior member of the board of examiners-in-chief of the United States Patent Office. From Jan. 15, 1908, they will continue the practice of patent law at the above address under the firm name of Byrnes, Townsend & Brickenstein.

Mr. William H. Bristol, manufacturer of indicating and recording pyrometers for all industrial uses, has recently moved his manufacturing departments, formerly located at Hoboken, N. J., and in New York City, to a well equipped factory at Broadway and Giles avenue, Jersey City. The main offices are still located at 45 Vesey Street, New York City.

Welding Flux.—W. A. Barnes, of Wornoco, Mass. has recently obtained a patent for a flux for welding copper. It consists of fine quartz sand, 2 parts; pulverized glass, 2 parts; soft copper fillings, 2 parts; borax, 8 parts; and cyanide of potassium, 2 parts. The ingredients are powdered and thoroughly mixed. The pieces of copper to be welded are heated, and are being kept covered with the above flux until white flakes begin to appear on the metal, and as it is then of the proper heat for welding it is hammered.

Chemical Stoneware.—The chemical stoneware business conducted in the past by Messrs. Frederick Bertuch & Co., and under the management of Mr. J. W. Sittig, has been transferred to Mr. Sittig, who is continuing it for his own account hereafter.

American Institute of Social Service.—As a recognition of the honor of decorations bestowed by the French Republic on Mr. Charles Kirchhoff, editor of *Iron Age*, Mr. T. Commerford Martin, editor of *Electrical World*, and Rev. Percy S. Grant, rector of the Church of Ascension, all of whom are members of its board, the American Institute of Social Service gave a dinner at the Aldine Club, New York, on Jan. 15. Hon. Elbert H. Gary, of the United States Steel Corporation, presided. The attendance was above 200. Following a speech of felicitation by Mr. John LaFarge on behalf of the French Consul General, the several honor guests were introduced to the assemblage. Mr. Wm. B. Dickson, vice-president of the United States Steel Corporation, introduced Mr. Kirchhoff; Mr. Frank J. Sprague introduced Mr. Martin, and Bishop Henry C. Potter introduced Mr. Grant. The concluding speech was made by Dr. Josiah Strong, who, in a convincing manner, told of the enormous and unnecessary loss of life, due to the lack of proper recognition of the avoidable risks in our modern industrial enterprises.

Memorial Exercises in Honor of Lord Kelvin.—In honor of the late Lord Kelvin, memorial exercises were held under the auspices of the American Institute of Electrical Engineers on the afternoon of Sunday, Jan. 12, in the "Engineers' Building." Mr. Andrew Carnegie was among the representatives of other national engineering societies which had been invited. President Stott, of the American Institute of Electrical Engineers, was in the chair. The programme included prayer and address by Rev. Dr. Wm. T. Manning, of Trinity Church, adoption of memorial resolutions, introductory remarks by President Stott, and addresses by Prof. Elihu Thomson on Lord Kelvin as an electrical engineer, by Prof. E. L. Nichols on Lord Kelvin as a scientist, by Mr. G. G. Ward on Lord Kelvin's work in submarine telegraphy, by Rear Admiral Geo. W. Melville on Lord Kelvin in naval engineering, and by Mr. T. C. Martin on Lord Kelvin and the American Institute of Electrical Engineers. Three of the speakers referred to the position which Lord Kelvin had taken in the Niagara power question, when he said that Niagara Falls will become truly beautiful only when no longer any water will go over the Falls, but the whole power will be developed and employed for useful work for the best interests of humanity.

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

No. 644,510, Feb. 27, 1900. Ellis F. Frost, Washington, D. C.

Feeds charge downward from a hopper having a fireclay mouth into an arc, sprung between the lower end of a vertical carbon electrode, depending centrally within the hopper, and a body of an electrolyte, for example, an aqueous solution of an acid or alkali. The carbid produced in the arc falls into the solution and generates acetylene. Or a layer of the electrolyte may be floated on a body of carbon bisulphide, a heavy hydrocarbon oil, or coal tar. The hot carbid then passes quickly into the next liquid. If coal tar is used, it coats the carbid into a protective layer.

No. 630,690, Aug. 8, 1899. Herman L. Hartenstein, Bellair, Ohio.

The blast-furnace slag used as a raw material for the production of compound carbides, in accordance with patents 596,704, 596,705 and 596,749, is variable in composition, and is sometimes deficient in calcium. Remedies this by injecting polarized limestone or quicklime, carbon and a reducing gas into the molten slag as it is drawn from the furnace, and then subjects the mixture to an electric current, as described in patent 596,749.

650,150, Aug. 14, 1900. William Smith Horry, New York, N. Y.

Calcium carbide is produced in a continuous furnace having special provision for withdrawing the reaction gases directly from the zone of reduction, under such conditions that the finely divided charge is not projected from the furnace and the operation becomes practically dustless. One furnace illustrated comprises a deep vertical casing having a hearth which may be progressively lowered; the electrodes are vertical, disposed entirely within the casing, and are deeply covered by the charge. The casing walls adjacent the electrodes are perforated to permit the free escape of gas, the charge being of sufficient depth to prevent any substantial escape of gas from the top of the casing. In operation a field of reduction is maintained at the top of the finished product and beneath the depending carbons by progressively lowering the hearth, the incoming charge gravitating around the electrodes. A modified construction is described in which the same principle of operation is applied to the rotary or wheel type of carbide furnace.

NEW BOOKS

JOURNEYS OF OBSERVATION.—By T. A. Rickard. Being the record of a journey from New York to Mexico, together with a description of the mining industry of El Oro, Pachuca and Guanajuato, as observed in October, 1905; also an account of a ride over the mountainous mining regions of Southwestern Colorado in September, 1902. 386 pages; 144 illustrations; 44 drawings. Price, \$3.50. San Francisco: The Dewey Publishing Co.

GENERAL FOUNDRY PRACTICE.—By A. McWilliam and Percy Longmuir. Illustrated. Price, \$4.50 net. Philadelphia: J. B. Lippincott & Co.

RUST PREVENTION.—By Lionel M. Stern. A treatise on the preservation of structural steel used in bridges, buildings, fire escapes, etc., and sheet steel used in buildings, metal siding, roofing, smokestacks, boiler fronts and standpipes, etc. 54 pages; illustrated. Price, \$1.00. Cleveland: Lionel M. Stern.

AN INTRODUCTION TO GEOLOGY.—By W. B. Scott. Second edition, revised throughout. 843 pages; illustrated from drawings by Bruce Horsfall, and from many new photographs. Price, \$2.60 net. New York: The Macmillan Co.

MINE GASES AND EXPLOSIONS.—By J. T. Beard. Text-book for schools and colleges and for general reference. 380 pages; 68 illustrations. Price, \$3.00 net. New York: John Wiley & Sons.

MINING INVESTMENTS AND HOW TO JUDGE THEM.—By Francis C. Nicholas. This book contains twenty-one chapters, covering such subjects as the organization, financial and physical development of mining properties; the relation of mining stocks to the properties back of them; reasons why mining companies fail, and also why they often succeed. 240 pages. Price, \$1.50 net. New York: Moody Corporation.

TECHNICAL METHODS OF ORE ANALYSIS.—By Albert H. Low. Third edition, partly rewritten. Price, \$3.00. New York: John Wiley & Sons.

TESTS FOR ORES, MINERALS AND METALS OF COMMERCIAL VALUE.—By F. L. McMecheen. 152 pages; illustrated. Price, \$1.25 net. New York: D. Van Nostrand Co.

THE ELECTROLYTIC DISSOCIATION THEORY WITH SOME OF ITS APPLICATIONS.—By H. P. Talbot and A. A. Blanchard. An elementary treatise for the use of students of chemistry. Second edition. 90 pages; illustrated. Price, \$1.25 net. New York: The Macmillan Co.

A SCHOOL CHEMISTRY.—By J. A. Waddell. Intended for use in high schools and in elementary classes in colleges. Second edition, revised and enlarged. 303 pages; illustrated. Price, 90 cents net. New York: The Macmillan Co.

QUANTITATIVE ANALYSIS FOR MINING ENGINEERS.—By Edmund H. Miller. Second edition, revised. 159 pages. Price, \$1.50 net. New York: D. Van Nostrand Co.

EXERCISES IN ELEMENTARY QUANTITATIVE CHEMICAL ANALYSIS FOR STUDENTS OF AGRICULTURE.—By A. T. Lincoln and J. H. Walton. 233 pages; illustrated. Price, \$1.50 net. New York: Macmillan Co.

SPECTRUM ANALYSIS.—By J. Landouer. Second edition, rewritten. 246 pages; illustrated. Price, \$3.00. New York: John Wiley & Sons.

PURE FOOD TESTS.—By Edwin M. Bruce. The detection of the common adulterants of foods by simple qualitative tests; a ready manual for physicians, health officers, food inspectors, chemists, teachers and all especially interested in the inspection of food. 91 pages; illustrated. Price, \$1.25 net. New York: D. Van Nostrand Co.

TEXT-BOOK OF PHYSIOLOGICAL CHEMISTRY.—By Olaf Hammarsten. Translated from enlarged and revised sixth German edition by J. A. Mandel. Price, \$4.00. New York: John Wiley & Sons.

COMPARATIVE ELECTROPHYSIOLOGY.—By J. C. Bose. A physico-physiological study. (This volume concludes the line of investigation on responsive phenomena in general which he began with the publication of a memoir at the International Congress of Science, Paris, 1900. In this first of his publications on the subject he undertook to show the similarities of response in inorganic and living substances. The method which he at that time employed for obtaining his response records was that of conductivity. His researches and observations in other directions, leading to the same results or very similar ones, are here described in detail. Classified list of experiments.) 793 pages; illustrated. Price, \$5.75. New York: Longmans, Green & Co.

INDUSTRIAL ALCOHOL.—By J. G. McIntosh. The production and use of alcohol for industrial purposes and for use as an illuminant and as a source of motive power. 266 pages; illustrated. Price, \$3.00 net. New York: D. Van Nostrand Co.

SOLUTION TENSION AND TOXICITY IN LIPOLYSIS.—By Raymond H. Pond. (Contributions from the New York Botanical Garden.) 259 pages. Bound in paper. 25 cents. New York: New York Botanical Gardens.

THE METRIC AND BRITISH SYSTEMS OF WEIGHTS, MEASURES AND COINAGE.—By F. Mollwo Perkin. 83 pages; illustrated by diagrams. Price, 50 cents net. New York: The Macmillan Co.

THE WEIGHTS AND MEASURES OF INTERNATIONAL COMMERCE.—By F. H. Hatch and E. J. Vallentine. Tables and Equivalents. 59 pages. Price, 80 cents net. New York City: Macmillan Co.

POWER STATIONS AND POWER TRANSMISSION.—By G. C. Shaa. A manual of approved American practice in the construction, equipment and management of electrical generating stations, sub-stations and transmission lines, for power, lighting, traction, electrochemical and domestic uses. Part 1, Power Stations; Part 2, Power Transmission. 155 pages; illustrated. Price, \$1.00. Chicago: American School of Correspondence.

HYDRO-ELECTRIC ENGINEERING.—By H. von Schor. Fully illustrated by original drawings, designs and photographs. Price, \$6.00 net. Philadelphia: J. B. Lippincott & Co.

THE ELECTRICAL TRANSMISSION OF ENERGY.—By Arthur V. Abbott. A manual for the design of electrical circuits. Fifth edition, entirely rewritten and enlarged. 705 pages; illustrated by 10 folding diagrams and 16 full-page engravings. Price, \$5.00 net. New York: D. Van Nostrand Co.

BOOK REVIEWS.

JOURNEYS OF OBSERVATION. By T. A. Rickard, editor of the *Mining and Scientific Press*. Octavo, 360 pages, profusely illustrated. Price, \$3.50. San Francisco: Dewey Publishing Co., 1907.

This is a modern version of the "Metallurgical Journeys" so often written in the nineteenth century. It is a cross between a finely-written book of travel and a metallurgical treatise on silver mining and extraction.

Exactly two-thirds deals with a trip to Mexico by sea from New York to Vera Cruz, and visits to El Oro, Pachuca and Guanajuato; the other third covers a trip across the San Juan Mountains in Colorado. It is sugar-coated metallurgical reading, such as can be done with ease and refreshment when tired after a hard day's work.

The photographs are nearly a hundred in number, and are beautiful; the word-painting is almost equally attractive and artistic; the print is a pleasure to the eye, and the paper completes the list of attractions, being unglazed and restful. The binding is rather too cheap and loud to match the virtues just catalogued.

The breeziness of the "wild and woolly" characterizes some of the author's observations, but his criticisms are not so

harsh as to be repulsive, yet are many times somewhat overdrawn. A little more just and even temper in referring to Wall Street and the capitalists who have done so much to benefit our great West would have drawn the author and his reflecting readers closer together.

Altogether, there is nowhere a better, or half as readable, account in print of metallurgical practice at El Oro, Pachuca, Guanajuato and over the San Juan Range than is here offered in silver plated literary style.

* * * *

DIE EISENHÜTTENCHEMIE. By Max Orthey. 258 pages; 36 illustrations. Price, 8 marks (retail price in New York, \$2.65). Halle. Wilhelm Knapp.

This work aims to be a practical handbook for the use of the chemist in the analysis of iron ores, iron and steel, fluxes, fuels, gases and refractory materials. The taking and preparation of the sample is first given the attention this important matter deserves. Methods of bringing the sample into suitable solution are next treated, after which the qualitative examination for the elements likely to be present is described in detail. On this point it may be said that, for some elements present in small amount, it will require little more time to make a final quantitative determination than is required to make a preliminary qualitative test.

The methods are clearly described in sufficient detail, and the iron chemist will find in the book many useful hints. Apparently, however, the reductor, so indispensable for neat, accurate and rapid work, is not well known in German practice, for in the reduction of the molybdenic solution in phosphorous determination, granulated zinc is used in an Erlenmeyer flask, followed by filtration from undissolved zinc in the old, unsatisfactory way.

* * * *

ILLUSTRATED TECHNICAL DICTIONARY IN SIX LANGUAGES—English, German, French, Russian, Italian, Spanish. Edited after a novel method by K. Deinhardt and A. Schlömann, engineers. Vol. II.: Electrical Engineering, including Telegraphy and Telephony. Compiled by Charles Kinzbrunner, A. M. I. E. E., consulting electrical engineer. 4,000 illustrations and numerous formulas. 2,100 pages. Price, \$7.00 net. New York: McGraw Publishing Co.

In our September issue, 1906 (Vol. IV., p. 372), we reviewed the first volume of this new series of illustrated technical dictionaries, which dealt with elements of machinery and machine tools. This is the second volume of this series, and deals with electrical engineering.

The novel arrangement adopted in the first volume is also followed in the second one. The whole volume (2,100 pages) consists essentially of two parts. The first part (1,356 pages) is not alphabetically arranged, but is classified rather like a handbook. It is divided into sixteen chapters, dealing respectively with cells and batteries, boilers and prime movers, electric machinery, switches, measuring instruments, electric supply stations, mains, house installations, lighting, various applications of electricity, telegraphy, telephony, electrochemistry, electromedical apparatus, units of measure and electrophysics, miscellaneous. Each chapter, again, contains the chief technical terms, as much as possible logically arranged. Each word is given in German, English, French, Russian, Italian and Spanish, and extensive use is made of diagrams, formulas and symbols to explain the different terms.

The second main part of the volume (740 pages) contains the alphabetical index of all the terms contained in the first part, with reference to the page where it appears. One index comprises the German, English, French, Italian and Spanish languages, while a separate index is provided for the Russian terms.

All the advantages of this arrangement which we pointed

out in our review of the first volume are again evident in the present volume, and it is probably true to say that it is the best electrical dictionary now available. Yet with respect to accuracy this second volume seems inferior to the first. Among numerous other mis-takes or inaccuracies we note here only the following:

On page 22, HgSO₄ is given as "mercury sulphate, mercurous sulphate, calomel." The last term is wrong, since calomel is mercurous chloride.

On page 100, Steinkohle, fossile Kohle is translated as "coal, pit coal," instead of bituminous coal.

On page 136, Dreiphasenstrom, Drehstrom is translated "three-phase [alternating] current, triphase a. e. (rotary or rotating current)." It is true the terms "rotary or rotating current" are put into parenthesis, but they are therefore not less ridiculous. Where in all the world have the editors of this dictionary found these terms except in other, older, dictionaries? Did they not intend to improve on the latter? Then they must omit such nonsense.

On page 1182, "elektrolytischer Wirkungsgrad, Stromausbeute" is translated "electrolytic efficiency." That is very indefinite. Stromausbeute is clearly ampere-hour efficiency.

On page 1183, "Überführungszahl des Anions" is translated "coefficient of migration of the anion," instead of the usual terms transference number or transport number.

On page 1192, the "Bäderraum" of an electrolytic plant is translated into "bath-room." While not directly wrong, it is funny. Let any German come to an American copper refinery and ask for the bath-room, and see whether they take him to the tank-house.

In the first edition of a volume of 2,100 pages, containing nothing but technical terms, it cannot be expected that all are correct. Numerous mistakes will undoubtedly be pointed out to the authors, and we sincerely hope that they will avail themselves of such information to carefully and rigidly overhaul the whole volume for the next edition. For, in spite of all deficiencies, the scheme of the dictionary, in the whole, is so admirable that it should deserve many editions.

* * * *

LA TECNOLOGIA DELLE SALDATURE AUTOGENE DEI METALLI. By Prof. S. Ragno. 129 pages; 18 illustrations. Price 2 lire (retail price in New York 50 cents). Milano: Ulrico Hoepli.

This little book, forming a volume of the well-known *Manuals Hoepli*, is probably the first monograph in any language on the autogeneous welding of metals. Besides general discussions the following methods are dealt with: Electric welding, welding with the oxyhydrogen, the oxy-acetylene and the oxy-illuminating gas flame, welding with thermit. The intention of the author is to give a general discussion of the essential principles without going deeply into details. As a concise summary of the subject which is now rapidly increasing in interest the little book should be useful.

* * * *

STATISTICS OF THE AMERICAN AND FOREIGN IRON TRADE FOR 1906. Annual statistical report of the American Iron and Steel Association. Philadelphia: The American Iron and Steel Association.

This report gives the complete statistics of the iron and steel industries of the United States for 1906 and immediately preceding years; also statistics of the coal, coke and ship-building industries of the United States, immigration, etc.; also more briefly statistics of the iron and steel industries of foreign countries. The following are the final total figures: The total production of pig iron in the United States in 1906 was 25,307,101 gross tons; basic and acid open-hearth steel, 10,980,413; Bessemer steel, 12,275,830; crucible steel, 127,513.

Electrochemical and Metallurgical Industry

VOL. VI.

NEW YORK, MARCH, 1908.

No. 3.

Electrochemical and Metallurgical Industry

With which is Incorporated Iron and Steel Magazine

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
239 WEST 39TH STREET, NEW YORK.

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH. D. *President*
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Yearly subscription price for United States, Mexico and United States dependencies, \$2.00; for all other countries, \$2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post-Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, MARCH, 1908.

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The Vapor Tension of Silver and Gold.

The instalment of Dr. J. W. Richards' Metallurgical Calculations, published in our present issue and dealing with the metallurgy of silver and gold, is particularly interesting and instructive. It is probably here for the first time that tables of the vapor tension of silver and gold are given. It is true, these are only estimates, but logical estimates based on plausible and practical rules, and undoubtedly the best estimates that can be made at present. As far as comparisons are possible with actual observations, the agreement is "encouraging," as the author says; we might say, it is surprisingly good. And as far as practical application of these tables is concerned, the figures will certainly be near enough the truth to base on them numerical calculations which may be relied upon as a first approximation. For that is the beauty of these tables, that they permit to draw from them very practical conclusions, and to base on them important commercial considerations.

* * *

There may still be practical men who consider "vapor tensions" to be pretty playthings for scientists. Possibly in some purely theoretical books they are handled that way. But if we consider that the vapor tension of a metal at a given temperature is nothing more nor less than a numerical indication of the extent to which the metal vaporizes at that temperature, and since these tables of Dr. Richards show that the vapor tension of silver at least reaches appreciable amounts at the temperatures of our smelting furnaces, they become immediately a matter of serious importance. The tables clearly indicate the danger of serious losses in melting in open furnaces where furnace gases pass over the metal. As Dr. Richards says, "Every smelter and refiner of the precious metals should be familiar with these facts, and draw conclusions from them useful to the conduct of his business."

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Electric Furnace Reactions Under High Pressure.

It is not always realized sufficiently that our ordinary chemistry relates to phenomena taking place within an extremely narrow range of temperature and pressure. From observations within this narrow range we are liable to deduct generalizations which, as such, are wrong. An example is Thomson's rule. At the zero point of absolute temperature it is strictly correct. At our ordinary temperature, which is relatively near absolute zero, it is approximately correct for most reactions, since the second term in the Gibbs-Helmholtz equation, which distinguishes it from Thomson's rule, is in most cases negligible at ordinary temperatures. This term contains the absolute temperature as one factor. The higher we go in the temperature the greater is the danger in applying Thomson's rule. Because Thomson's rule is practically true in most cases

at ordinary temperatures, it would, therefore, be wrong to conclude that it is also true at high temperatures. We may have at high temperatures a chemistry quite different from that of low temperatures. Elements which do not react at all at low temperatures, like the nitrogen and oxygen in the air, combine eagerly at the temperature of the electric arc.

* * *

Enormous progress has been made in recent years in extending the range of temperatures available for research, in both directions, towards high and low temperatures. High temperatures are the field of electric furnace research, and it is unnecessary to point out here how this research has resulted in the establishment of a number of new important industries like those of carborundum and calcium carbide. Further avenues of research are opened by not only varying the temperature but also the pressure. Some very interesting electric furnace experiments with high pressures are described in the paper by Dr. Hutton and Mr. Petavel in our present issue. The possibilities of a process of direct reduction of alumina by means of carbon, discussed by the authors, are so attractive—even though the matter is not beyond the purely experimental stage—that these high-pressure high-temperature researches should attract most careful attention. It would seem promising to apply the same method to other reactions, and to study them not only at high gaseous pressures but at low pressures, for the high-pressure furnace appears to be equally suitable as a vacuum furnace. Messrs. Hutton and Petavel certainly deserve our thanks for having opened a new field with considerable skill, perseverance and success.

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Changes in British Patent Law.

Some recent changes in British patent law are interesting on account of the importance of the new rules to manufacturers, and should be especially interesting to our readers, because in the arguments made for the new law the development of the dyestuff industry has played an important part. It is a fact that the dyestuff industry was born in England. Perkin's discovery of mauve and A. W. Hofmann's pioneer work in England are history. But it is also unnecessary to describe how England permitted Hofmann to return to his native country, Germany, and how the whole dyestuff industry gradually passed from England over to Germany. Out of all patents granted in England in 1906 for dyes, 95 per cent were granted to foreigners. Moreover, the manufacture was carried on almost completely abroad, and the products imported into Great Britain in large quantities. In other words, the British patents were merely used for the purpose of shutting others off from the British market, not for creating a productive British industry.

* * *

The method by which England tries to meet this situation was already foreshadowed by the action of Canada, where an act was passed in 1903, according to which a patent is null and void at the end of two years unless the patentee shall commence and continuously carry out in Canada the construction or manufacture of the invention patented in such a manner that any person desiring to use it may obtain it at a reasonable

price by some manufactory in Canada. Further, "if after twelve months from the granting or authorized extension of a patent the patentee imports into Canada the invention for which the patent is granted, such patent shall be void as to the interest of the person so importing." The chief features of the new English patent law, to which we shall now refer, are in the same direction.

* * *

One of the fundamentally new features of the British law, which went into effect at the beginning of this year, is that before an English patent is granted there shall be a search of the prior art, and the principle, long recognized in this country and elsewhere, of refusing a grant of a patent on the ground of anticipation has now, for the first time, been adopted in England. More important, however, are the new rules as to the use of a patent. There is a rule that any person interested may present a petition to the Board of Trade (a British government department which has power and control in patent matters) alleging that the reasonable requirements of the public with respect to a patented invention have not been satisfied, and praying for the grant of a compulsory license, or, in the alternative, for the revocation of the patent. The Board of Trade are to consider the petition, and if the parties do not come to an arrangement between themselves, the Board, if satisfied that a *prima facie* case has been made out, must report the petition to the Court, but if the Board are not so satisfied they may dismiss the petition. When such a petition is referred to the Court, and it is proved to the satisfaction of the Court that the reasonable requirements of the public with reference to the patented invention have not been satisfied, the patentee may be ordered by the Court to grant licenses on such terms as the Court may think just; if the Court is of opinion that the reasonable requirements of the public will not be satisfied by the grant of licenses, the patent may be revoked. An order of revocation will not, however, be made before the expiration of three years from the date of the patent, or if the patentee gives satisfactory reasons for his default.

* * *

It will be, of course, of greatest importance to see how the term "reasonable requirements of the public" will be understood by the British courts. Other important provisions are intended to prevent a patentee, whether British or foreign, from placing such restrictions on the use of his invention that the public is unduly hampered in its use of it. In any contract made in relation to the sale or lease of or license to use or work any article or process patented it shall be illegal to insert a condition: "to prohibit or restrict the purchaser, lessee or licensee from using any article or class of articles, whether patented or not, or any patented process, supplied or owned by any person other than the seller, lessor or licensor, or his nominees; or to require the purchaser, lessee or licensee to acquire from the seller, lessor or licensor, or his nominees, any article or class of articles not protected by the patent." Any such conditions in a contract shall be null and void, as being in restraint of trade and contrary to public policy. It will be seen that the new British patent law contains very important innovations. This country, like others, believes in protective duties to aid the home industry. England believes

in free trade, and tries to create home industries by its patent law. It will be worth while watching how this scheme will work in practice.

The Industrial Situation.

Commercial developments in the past few months prompt us to scrutinize, from a fresh viewpoint, if possible, what we have done in the past ten years, that we should have to face the conditions which now confront us. These have been years of apparently great prosperity, yet we have less than we expected of strength financially, and of momentum industrially. Not to anticipate too much, we can say at least that our profits appear to be, to some extent, paper profits, while our increasing rate of production appears to have overstocked us. We have been primarily an agricultural nation, but it is not from agriculture that any trouble has developed. Our past crops have been finally consumed, and there is demand for more of these products. By various enlightened methods the dangers of crop famine have been reduced to almost negligible proportions.

* * *

In manufacturing, one naturally turns to the iron industry. For ten years—eleven, to be complete—each year, with the exception of 1904, has broken all previous production records. The year 1898 broke the 1897 production record by more than two million tons, turning out 11,773,934 tons. Last year completed the period, with an output of 25,781,361 tons. Apparently there was no expectation on the part of our iron producers that demand was to call a halt, since new furnaces have been projected right and left. During 1907 there were completed and blown in, fifteen absolutely new furnaces, with an annual capacity of 2,100,000 tons, the last accretion being in October. They brought the country up to January 1, 1908, with an actual productive capacity in excess of 28,000,000 tons, and yet that was not all. There were new furnaces being built, many of them almost completed, and all, no doubt, ultimately to be completed, having an annual capacity of 3,500,000 tons, so that right in the close of this period of activity an annual production of 31,500,000 tons was being provided for. Our exports need not be considered. They were a trifle less in 1907 than in 1906, and do not promise a gain this year. At best they have not represented a pig-iron equivalent of more than a million and a half tons, negligible against a capacity for more than thirty millions. Evidently the expectation of producers was that as the country increased its purchases year by year, it would continue indefinitely to do so. Possibly they failed to observe that men do not eat iron, but put it into employment.

* * *

During the past ten years, 1898 to 1907, there have been produced in the United States 181,470,757 gross tons of pig iron. Our population being about 86,800,000, there have been produced in ten years 2.1 tons of pig iron for every man, woman and child in the United States. In the preceding ten years the production was 82,236,958 tons. In all the years prior to 1888 the aggregate was less than 100,000,000 tons, so that in the last ten years we have made more than in all the past. A relatively small part of the iron used disappears. What was produced two or three decades ago may be lost, but the ton-

nage then made was insignificant. The bulk of what has been produced in the past two decades has survived. Occasionally it may be remelted in the foundry cupola or the open-hearth furnace, or the pieces may be stuck together by heating "piles on boards" and the other devices of the iron mill. Certainly more than two tons per capita have survived, and with the exclusive use of two tons, each one of us in this country can accomplish quite a good bit, yet provision is being made for distributing a third of a ton additional every year, so that while we are using two tons apiece now, six years hence we should be using four tons apiece. It should not be new to our readers that the recent pace in expansion has been rapid. In our market review last March we discussed the prospective new capacity and concluded: "The presentation should be conclusive that a very large increase in production is possible over 1906, while trade conditions do not warrant the belief that there will be any material increase in consumptive demand." The actual increase in make in 1907 was 475,000 tons, or less than 2 per cent, and the year closed with a capacity equal to an increase of more than 10 per cent. This is really a period in which we are removing iron ore from the ground, dissociating the iron, and not consuming it, but putting it into use. We are not in the infancy of the period, but have progressed well along to maturity. This may lead to the conclusion, then, that we must look upon the past ten years in the iron industry not so much as setting a pace as accomplishing a result, and halting at its close until more results are required.

* * *

In our international trade we have had a tendency to overlook forces at work which were readily discernible. When our trade in 1898 showed the record favorable balance of trade of \$620,000,000 there was congratulation. The following year there was a favorable balance of \$476,000,000, which was the best, barring 1898, while 1900 established a new record, with \$649,000,000, and then came 1901 with \$585,000,000. In these four years, 1898 to 1901, our apparent favorable balance of trade was \$2,331,000,000, or \$583,000,000 per year. That has furnished the basis for much of our prosperity. But of late years the balance has not been so good; in the past four years it has averaged only \$460,000,000 per year. That decrease is bad, but it is far from being the whole story. In 1898 to 1901 our average commerce, imports plus exports, was \$2,155,000,000 per year. In the past four years it has been \$2,940,000,000 per year. The apparent favorable balance of trade is not net profit; it is gross earnings, from which must be deducted expenses, such as the freights we pay on both incoming and outgoing merchandise, the money our tourists spend abroad, a percentage of loss on the total business transacted, because we always undervalue our imports and overvalue our exports, and a number of other items. The business we transacted in the past four years was more than a third larger than that in 1898 to 1901, while our gross earnings were more than one-fifth less. Necessarily our net profits have been greatly reduced, yet in the recent past we have seen much of glorification over the enormous amount of foreign business we have been doing, with no serious thought as to whether we are gaining or losing by it. Not having provided a basis for the future with careful foresight, we must now seek one in our embarrassment.

The Iron and Steel Market.

The iron trade has settled down to a long wait for the rehabilitation of demand. The policy which dictated the maintenance of 1907 steel prices was an unhelpful one, because it did not recognize that demand could be stimulated by reduction in prices, i. e., by anything at all. At first the policy was criticized; it still is, but in much less degree, because more men have become convinced that there is little business to be had at any price.

The mills are operating, on an average, between 30 and 40 per cent of the normal. Statements are frequently made crediting them with 50 per cent or more. Such statements are either untrue fundamentally or err in misusing the term normal. For almost three years, up to last November, the American iron and steel industry was operating up to its capacity, which was continually increasing, and normal in this connection should mean nothing but operating to existing capacity; or, in other words, at a rate equal to the greatest yet attained.

As predicted in last report, ore prices were fixed for the forthcoming season at the same rates as prevailed last year. A meeting was held in Cleveland Feb. 7 at which all but one of the ore interests were present, and they, the absent interest afterwards concurring, expressed the determination not to sell any ores for the coming season at less than last year's rates, with the same analysis basis. These rates are:

Old range Bessemer.....	\$5.00
Old range non-Bessemer.....	4.20
Mesabi Bessemer.....	4.75
Mesabi non-Bessemer.....	4.00

These prices are f. o. b. Lake Erie docks. The Bessemer ore basis is 55 per cent iron in the natural state, with 10 per cent moisture, and .045 per cent phosphorus when dried at 212°. The non-Bessemer basis is 51.50 per cent iron in the natural state, with 12 per cent moisture. Ores above and below the basis take premiums and penalties. This basis was first established last year. For a number of years prior the basis was 63 per cent iron for Bessemer and 60 per cent iron for non-Bessemer ores, dried at 212°, with the same moisture content in the natural state, which made the percentages in the natural state 56.70 and 52.80 per cent, respectively. The penalty system for ores under the base is substantially the principle that the iron is sold on a unit basis, which is inequitable to the consumer, as it does not reimburse him for the extra coke and limestone consumed in smelting.

It is not expected that any ores will be sold for months to come on the established or any other basis. The Cleveland ore firms were at first much averse to fixing any prices at this time, and were induced to take the action only by the persuasion of the steel interests, who wished assistance in the efforts to maintain old prices for steel products.

Very little Lake Superior ore will be mined this year. A preliminary statement of the United States Geological Survey indicates that production in the Lake Superior region last year was about 43,000,000 tons, and production of the entire country between 52,000,000 and 54,000,000 tons. The Lake Superior production is based substantially on the prospective make in the districts tributary to it for the period July 1 to July 1. As districts using other than Lake Superior ores have been changing their capacity but little, it is not necessary to segregate. The pig iron output from July 1, 1906, to July 1, 1907, was about 26,000,000 tons, corresponding to the production of 47,750,000 tons of iron ore in the calendar year 1906. The prospective pig iron output from July 1, 1907, to July 1, 1908, allowing for the new furnaces coming in, was about 28,750,000 tons, and on this the production of about 53,000,000 tons of iron ore in the calendar year 1907 was based. The figures correspond very well. However, the actual make in the second half of 1907 was only 12,300,000 tons, and the prospects are that the

make in the present half-year will lie between 7,000,000 and 9,000,000 tons, making a production for the year, July 1, 1907, to July 1, 1908, something like 8,500,000 tons less than the prospect. It is not probable that the prospective make for the twelvemonth following July 1 next will approach the output of the calendar year 1907, even curtailed as it was in the closing two months to a total of 25,781,361 tons. Supposing it to reach 20,000,000 tons, there would be a surplus of ore to take care of 8,500,000 tons of it, leaving only 11,500,000 tons to be taken care of by ore production this year, just 40 per cent of the pig-iron make on which the 1907 ore production was based. Assuming so much as 25,000,000 tons of pig iron expected for the twelvemonth beginning July next, there would be 16,500,000 tons to provide for, less than 60 per cent of the previous prospect, so that it is reasonable to conclude that iron ore production in 1908 will lie between 40 and 60 per cent of the production of 1907. Pig iron production in 1908, on the other hand, is likely to be two-thirds the output of 1907.

PIG IRON.

On the whole, there has been an increase in pig iron production by steel interests in February as compared with January, while the output by merchant furnaces has decreased. The steel interests were quick to blow out their furnaces on the sudden decline in demand, while the merchant furnaces, largely involving detached operations, accumulated some stocks of different grades before blowing out in order to supply such demand as might develop during the period of idleness. The market was extremely dull in the early part of February, but in the closing fortnight of the month took on a little more activity. The buying has been of the most conservative character and prompted only by necessity. The market is steadier than a month ago and is not materially lower. It can be fairly quoted, f. o. b. valley furnace, at \$17 for Bessemer, \$16 for No. 2 foundry and basic, \$16 to \$16.25 for malleable, and \$15.25 for gray forge. An agreement upon foundry iron among a number of central western furnaces has an academic interest only at present, since iron can be bought at less than the agreed prices. These are on the basis of \$17, delivered Pittsburgh, Youngstown, Cleveland and Detroit, plus the switching charge from the local furnace nearest the point of delivery.

STEEL.

It is understood that the mills are adhering to the agreement at \$28, Pittsburgh, for standard billets, and \$29, Pittsburgh, for sheet bars, with full extras on sizes and carbons. On account of the existence of small stocks here and there, and the possibility of putting through some trades with scrap and pig iron, some middlemen are able to offer small lots of billets at \$1 to \$1.50 under the agreed price. With so very light a demand these offerings make the market, but any ordinary activity would, it is to be presumed, clean up all such cheap steel.

FINISHED MATERIAL.

Fresh sales have been extremely light. They are lighter than they would be in normally dull times. It is a question whether the extreme stagnation is attributable more to lack of confidence in the programme of maintaining finished steel prices, or to inability of consumers to finance transactions. Certainly while general business is quiet there is less iron and steel business than there should be.

There has been a disappointment in rails. The Pennsylvania system, which is usually the leader in placing season orders, bought only 55,000 tons for 1908. After last season's deliveries were closed it had 30,000 tons still due, while besides this it had rolled, under special arrangements, 11,000 tons, making its total supply for the current year 96,000 tons. For four preceding years its purchases have ranged from a minimum of 102,000 tons to a maximum of 225,000 tons. The Pennsylvania system embraces 5 per cent in length, and much more in interest, of the country's total railroad mileage, so

that the rail outlook is very bad, seeing that the 1906 production amounted to about 4,000,000 tons.

While the size of the Pennsylvania order was a disappointment, another came in that other railroads did not follow as they have usually done. Two-thirds of the tin-plate mills of the country are in operation, this branch showing more activity than any other. Ordinarily, however, the months of February and March see all the tin mills in operation, with shipments in excess of production and drawn partly from stocks accumulated against the canning season. Tin-plate production in the three months since December 1 last has been just about one-half what it was a year ago, despite the traditions that tin plate fares best when other lines are dull, that men must eat, and that nature does not suspend the laws of decay as to canning crops when industrial conditions are bad.

No changes have been made in finished steel prices, the producers still adhering to the policy that prices should be maintained through this period of stagnation and be reduced only when conditions show that there is some activity ahead. Plates remain at \$1.70, but are shaded by some smaller mills to \$1.60; shapes are on the \$1.70 basis, but one mill at least has been doing \$1.60; merchant steel bars are \$1.60, tin plates \$3.70, black sheets \$2.50 and galvanized sheets \$3.55. Wire products are firm, on the basis of \$2.05 for nails. The iron mills have advanced their prices to the basis of \$1.50 for Pittsburg delivery, \$1.50, f. o. b. Pittsburg, for eastern delivery, and \$1.47, f. o. b. Pittsburg, for western delivery. The advance was made partly in deference to the strongly expressed wishes of the steel interests, and partly because the low prices had brought out little business.

American Institute of Mining Engineers.

The annual business meeting of the American Institute of Mining Engineers was held in the United Engineers' Building, in New York City, on Feb. 18. The following officers were elected: John Hays Hammond, president; J. Parke Channing, John B. Farish and F. W. Denton, vice-presidents; Joseph H. Shockley, C. R. Corning and R. Van A. Norris, members of council; James Douglas, James F. Kemp and Albert R. Ledoux, directors; R. W. Raymond, secretary.

In the absence of President Hammond, who is ill at San Francisco, Vice-President Prof. Henry M. Howe was in the chair at the evening session of Feb. 18. Dr. R. W. RAYMOND presented in abstract a suggestive paper on Humboldt and Swedenborg as mining engineers. Mr. DAVID B. RUSHMORE read an interesting paper on electric power in steel mills, profusely illustrated by lantern slides and covering the principal features of generation and applications of electric power down to the application to the driving of rolling mills.

At the morning session of Feb. 19, Mr. F. E. Junge spoke on the use of waste gases in German steel works.

THE WATERTOWN ARSENAL STEEL TESTS.

Mr. J. E. HOWARD presented a paper on the scope of the work of the testing department of the Watertown Arsenal in its relation to the metallurgy of steel. As to tests of ingot metal, open-hearth, Bessemer and crucible steel, fluid compressed and uncompressed, the chief item of the inquiry is to be the conditions of structural soundness and continuity of the metal in the ingot state, because this is of utmost importance in the behavior of the steel after having undergone further treatment.

Other subjects of systematic tests will be blooms, billets and rolled and hammered shapes from ingots, including finished products of all kinds. The object of these tests will be to determine the influence of the working temperature on final properties, to determine how much work is essential at a given temperature to get maximum tensile strength, etc.; also

reductions in the rolls or under the hammer and the number of passes in the rolls will be inquired into.

In the discussion of this paper, in which Messrs. R. W. Mahon, A. A. Stevenson, C. L. Huston, F. N. Speller, J. P. Snow and C. S. Churchill participated, various subjects were proposed which should be investigated at the Watertown Arsenal laboratory.

Mr. C. L. HUSTON (in a communicated discussion) pointed out how, by varying the method of heating and the manipulation in the rolls and the proportion of the test pieces, it is possible to adjust yield point, elongation and reduction of area. Besides the proposed division into grades, such as open-hearth, Bessemer and crucible steel, a careful distinction should be made between mild steels, medium-carbon steels and high-carbon steels and the various special alloy steels, because these different classes behave very differently in cooling and solidifying from the molten state, and this has naturally a great effect on uniformity in chemical composition and structural continuity. It would seem probable that work performed on steel at the higher temperatures above the recalescence point will have little effect on the properties of the final product, because the work done at the higher temperatures has only a small permanent influence on the structure of the steel. For boiler and structural work Mr. Huston favors the use of soft steel, on account of greater safety.

Mr. F. N. SPELLER expressed his agreement with the opinion of Mr. A. A. Stevenson, that all investigations of the origin of the defects in steel should go back of the ingot and should start with the metal from the blast furnace, taking duly into consideration its composition, treatment, refining, ladle reaction, oxidation, etc. As an instance, he mentioned the manufacture of soft steel, using ferro-manganese for the deoxidation of the metal; in a given case it may be possible to get such a good reaction in the ladle that practically all the oxides formed are absorbed by the slag. If, however, the pig iron is only slightly different, with respect to the amounts of silicon, manganese, etc., which it contains, the condition may be so completely changed that the slag in the ladle is unable to absorb the oxides from the steel, and this will naturally result in more or less trouble all through the further treatment of the steel, although the chemical composition and structure of the ingot may not be abnormal.

Mr. J. P. SNOW suggested investigations of the origin of crescent breaks of rails, of which there have been a great many during the last cold winter. He distinguished two types of flaws, the one being due to gas bubbles in the ingot and the other being rolling flaws, showing cracks or folds in the surface of the ingot or bloom. He suggested that tests be made at the Watertown Arsenal to discover the origin of both kinds of flaws. In the case of low-carbon steels, holes will weld up much better during the rolling operation than in high-carbon steels, but comparatively high-carbon steel must be used for rails.

Mr. C. S. CHURCHILL suggested that a most important subject for investigation would be the effect of different methods of rolling steel from ingot to bloom and from bloom to finished shape, like the effect of variation of reduction, variation of the number of passes and the effect of the time element.

PIPING AND SEGREGATION IN STEEL INGOTS.

Prof. HENRY M. HOWE's long paper, presented at a former meeting of the Institute, was the subject of considerable discussion.

A long discussion by Mr. P. H. DUDLEY pointed out that according to his experience the most essential thing for the production of sound ingots is to allow more time for recarburizing either in the converter or ladle before teeming. The shortening of the time in the Bessemer department from recarburizing to teeming has contributed to the inferior product of Bessemer rails in large outputs. Segregation in the long ingots, particularly with 0.1 phosphorus, is a serious thing for

modern high-speed traction. But with respect to wear, high-carbon low-phosphorus rails are a good deal better. Basic open hearth steel, in the manufacture of which proper time is allowed for the escape of the oxidation products, has proven exceptionally tough and free from oxides and included slag. Its rate of wear seems to be slow and it seems to offer high safety in sections as girders.

Mr. Dudley mentioned 95-pound rails high in carbon and low in phosphorus, made from 14-inch ingots in 1891 and 1892, most of which are still in the track. In making them, after carburization in the converter, the metal was poured and remained in the ladle 5 to 6 minutes, to allow the chemical reaction to go on and the oxides to escape before teeming; the ingots, which were stripped, were then thrown down in the pits and charged into horizontal furnaces for equalizing the heat before blooming. The blooms were cropped until sound steel was obtained, then chipped under the steam hammer, and again charged into horizontal furnaces for reheating, and finally rolled into rails in eleven passes. For finishing a temperature between 950° and 1,000° C. was used.

Mr. Dudley thinks that the marking of rails which has been practiced by some companies in the past will be required by every mill in the future. Since 1893, Scranton rails were marked A, B and C for the top, middle and bottom rails from the ingots. Imperfections were mostly found in the A rails.

Prof. H. M. Howe, in discussing the subject, did not think that large size is the chief cause of segregation. Although individual cases may differ considerably, greater quantities of large and of small ingots will give about the same average in segregation.

Mr. H. W. Hixon expressed the opinion that the open-hearth process gives better rails, because the occluded gases have time to escape. With the electric furnace steel process even better results must be obtained, since there will be no occluded gases. He also suggested the use of a steel mixer, or reservoir, in which time is given to the steel to get rid of the gases before it is put into the ladle.

Dr. R. W. Raymond also referred to electric steel processes, and mentioned the remarkable high quality of the steel produced in the Héroult furnace, which he had seen in operation in Germany. He also thought that the good results obtained with this process are chiefly due to the fact that the steel remains molten long enough in the furnace to let the gases escape. Mr. A. A. Stevenson thought that segregation is of little moment if enough of the top of the ingot is discarded. Dr. Wm. Campbell emphasized that in finishing the proper temperature is of importance. The amount of reduction in the rolls also determines the properties of the product.

In the afternoon session of Feb. 19, Mr. THOMAS H. LEGGETT presented a paper on present mining conditions on the Rand in South Africa, while Mr. T. LANE CARTER spoke on the Chinese on the Rand.

FUEL BRIQUETTING.

An interesting, brief paper by EDWARD W. PARKER described a briquetting plant installed at the Bankhead Mines in Canada. The coal is anthracite, but more friable than Pennsylvania anthracite, so that more dust is produced. This was formerly wasted but is now utilized. The analysis of the coal is 83.5 per cent fixed carbon, 8 per cent volatile matter, 8 per cent ash and 0.5 per cent moisture. The briquetting process employs pitch as a binder, the pitch being introduced into the coal dust with the aid of an atomizer. One plant with a capacity of 10 tons per hour is in operation, while a second plant of the same size is in course of erection. Both plants when in operation will have an output of about 15,000 tons per month. The briquets sell at \$4.00 per ton at the plant.

Mr. WILLIAM H. BLAUVELT then gave data on the Smet-Solvay briquetting plant at Detroit. Coke breeze is briquetted with pitch as a binder, but in view of the limited amount of coke breeze available some anthracite is mixed with it. Since the briquets are sold in competition with anthracite, freedom

from smoke is a requirement. Mr. Blauvelt sketched the results of briquetting methods in making commercially useful the lignites and semi-lignites of the Far West. For steam raising large briquets are preferable, while for use as fuel in houses small briquets are more desirable. There are now seven plants in operation for the making of such small briquets. The total cost of briquet making, including both the cost of the briquetting operation and the cost of the pitch, ranges from \$1 to \$1.60 per ton.

Dr. JAMES DOUGLAS referred to the difficulty of tar not being available everywhere. Mr. Blauvelt, in discussing the possibilities of by-product coke ovens in the West, said that there would be no difficulty to sell coke in the West but in selling tar. Dr. Douglas thought that the tar could be sold to the railroads, but he questioned whether there would be a market for the ammonium sulphate in the West, since our Western farmers are not yet acquainted with artificial fertilizers.

Mr. N. LILIENBERG discussed the artificial compression of semi-liquid steel ingots in the special apparatus which he has devised for this purpose, and by means of paraffine ingots he showed what results can be obtained.

At the evening session of Feb. 19, Dr. Joseph A. Holmes gave data on recent coal mine disasters in this country. Feb. 20 and 21 were devoted to various excursions.

Western Association of Technical Chemists and Metallurgists.

The third general convention of this young and vigorous society, which has now some 300 members, was held in Deadwood, S. D., from Jan. 2 to 4. Papers were presented by H. W. Harding, on the conical tube mill; by J. M. Tippet, on cyanide clean-up at the Portland mill; by Willett Barton, on an assay scheme for cyanide solutions; by J. B. Ekley, on a new and short method for the determination of tungstic acid in wolframite ores; by G. A. Burrell, on the calorific value of coal as determined by the Mahler bomb calorimeter; by J. M. McClave, on tabling roasted ores, and by M. F. Coolbaugh, on a new method for the determination of arsenic. Various very instructive excursions were made to cyanide works at Deadwood, Lead and Pluma. A South Dakota section of the association has been organized.

Society of Chemical Industry.

At the meeting of the New York Section of the Society of Chemical Industry, held on Feb. 14 at the Chemists' Club, Dr. Charles Baskerville presented a very suggestive paper on the injury to vegetation by the fumes from chemical factories. One particularly interesting point brought out at the conclusion of the paper was the enormous amount of sulphur dioxide set free in the atmosphere of a city like New York during a year from the burning of coal for heating purposes. Figures were given of air analysis at various points in New York City. Since electric heating is practically out of question, there seems no other possible remedy but burning producer gas for heating purposes.

Mr. E. A. Sperry spoke on the preparation and uses of anhydrous tetrachloride of tin. As well known from various recent patents of Mr. Sperry, he has been much interested in detinning by means of chlorine for the production of tin tetrachloride. Mr. Sperry remarked in his paper that anhydrous tin tetrachloride has been heretofore a scientific curiosity, but that the anhydrous liquid (as made by a distillation process) will be, in his opinion, the form in which tin tetrachloride will be used in future.

Dr. Maximilian Toch finally spoke on the influence of sunlight on paints and varnishes. In this paper the distinguished paint chemist gave for the first time some of the results of

his researches of many years to the public. All three papers were discussed at some length.

After the conclusion of the meeting of the Society of Chemical Industry the annual meeting of the Verein Deutscher Chemiker, with election of members, was held.

American Electrochemical Society.

The annual spring meeting of the American Electrochemical Society will be held in Albany, N. Y., on April 30, May 1 and 2 (Thursday, Friday and Saturday). The proximity of Troy, Schenectady and important water-power plants will lend interest to excursions in connection with the meeting. We will publish the program of the meeting in our next issue.

At the meeting of the Board of Directors, held in Philadelphia on Jan. 28, the following gentlemen were elected members: J. Robert McFarlin, Electric Service Supplies Co., Keokuk, Ia.; James Aston, Thos. Aston & Son, Milwaukee, Wis.; George E. Lond, University of Wisconsin, Madison, Wis.; Rudolf Albrecht, the Sun Co., Marcus Hook, Pa.; George R. Kendall, McGill University College, Vancouver, B. C.; Edward Zarembo, American Foundry & Machine Co., Chicago, Ill.; Otto Mantius, American Foundry & Machine Co., Chicago, Ill.; Johan Fr. Irgens, Technisk Bureau, Ltd., Bergen, Norway; Walter H. Aldridge, Canadian Pacific Railway, Trail, British Columbia.

At the meeting of the Board of Directors, held in New York City on Feb. 29, the following gentlemen were elected members: Herbert C. Jennison, Coe Brass Manufacturing Co., Ansonia, Conn.; Percy A. Boeck, Norton Emery Co., Worcester, Mass.; William C. Marti, University of Illinois, Urbana, Ill.

The First Mendelejeff Congress.

The first Russian Mendelejeff Congress, in which both chemists and physicists participated, was held in January in St. Petersburg, in honor of the memory of the late D. Mendelejeff. For the following report we are obliged to Prof. Alexander Krakau, of the Electrotechnical Institute of the Emperor Alexander III., at St. Petersburg.

The Congress was opened on Jan. 2, 1908, by Prof. I. Borgman, chairman of the executive committee and president of the University of St. Petersburg, who reported on the organization of the Congress, and proposed Prof. N. Beketoff, the oldest of the Russian chemists and a member of the Russian Academy of Science, as chairman of the Congress. The motion was carried with great enthusiasm.

Three sessions of the Congress were devoted wholly to the memory of Mendelejeff. During the first of these (Jan. 2) numerous messages of congratulation were received from various municipal and educational institutions and societies, etc., and papers were presented by Prof. W. Tischenko, on the life of Mendelejeff; by Prof. V. Kurbatoff, on the scientific work of Mendelejeff, and by Prof. N. Beketoff, on the importance of the periodical system.

In the second session (Jan. 5) Prof. G. Gustavson spoke on Mendelejeff and organic chemistry; Prof. P. Walden, on the work of Mendelejeff on solutions; Prof. B. Weinberg, on the work of Mendelejeff on Capillarity and "the temperature of the absolute boiling point"; Prof. F. Kapustine, on the work of Mendelejeff on the variations of volume of gases and liquids, and Prof. G. Jukowsky, on Mendelejeff's investigations of the mechanical resistance of liquids and aerial locomotion.

In the third session (Jan. 12) Prof. A. Wojeikoff discussed Mendelejeff's researches in meteorology; Prof. K. Harychkoff, the work of Mendelejeff on Russian and American naphtha and its industry; Prof. P. Rubzoff, Mendelejeff's investigations on explosive substances, and Prof. N. Yegoroff, the work of Mendelejeff on the standards of weights and on precise measurements in general.

In the intervals between these solemn sessions other meetings were held under the auspices of the different sections into which the Congress was divided, according to its organizations, as follows:

Six joint sessions, in which papers were read on physical chemistry and others of a nature to interest both chemists and physicists.

Nine sessions of the Section of Pure and Applied Chemistry and Electrochemistry, in which seventy-seven papers were read.

Four sessions of the Section of Physics, in which twelve reports and fifteen experimental lectures were presented.

In the Section of Agricultural Chemistry twenty-three papers were read.

In the Section of Biological Chemistry thirteen papers were presented.

During one of the sessions held at the Electrochemical Institute, A. Lodyguine, honorary electrical engineer, spoke in behalf of the American Electrochemical Society, which had sent by cable its congratulations to the Congress.

The following resolutions were adopted by the Congress to honor the memory of Mendelejeff:

1. To erect a monument to Mendelejeff in front of the University of St. Petersburg, where Mendelejeff spent most of his life, and to open an international subscription for this purpose.

2. To found a "Mendelejeff Institution," which is to consist of

- a. A Mendelejeff Museum of Pure and Applied Chemistry, where are also to be preserved all sorts of souvenirs of the work and private life of Mendelejeff.

- b. A library and laboratories, in which scientists could make studies and investigations of a kind impossible in most laboratories.

- c. A large hall, for the use of celebrated foreign scientists that would be periodically invited to deliver lectures and award the "Mendelejeff Medal."

3. To organize periodical "Mendelejeff Congresses" of chemistry and physics.

The first Congress was attended by more than a thousand members.

The second Congress will be held at St. Petersburg in January, 1909, to celebrate the seventy-fifth anniversary of the birth of Mendelejeff.

Autogenous Welding of Aluminium.

We have referred repeatedly to Mr. M. U. Schoop's method of autogenous soldering of aluminium which the inventor exhibited some time ago at his presence in New York City before the Chemists' Club.

A stock company for the exploitation of this invention has now been formed in Zurich, Switzerland, with a capital of 1,000,000 francs (\$200,000). Prof. Dr. von Salis is the president and Messrs. J. H. Frey and M. U. Schoop are among the directors. It is expected that in view of the recent drop of aluminium prices in Europe the use of aluminium for manifold purposes will increase rapidly and extensively, and that the new simple process of autogenous welding of aluminium will have a bright future in this development.

From a recent paper of Mr. M. U. Schoop in the *Chemiker Zeitung* it now appears that the flux which he uses is an aqueous solution of some alkali metal chloride; for instance, a chloride of potassium sodium or lithium, but from what Mr. Schoop stated here in the Chemists' Club it may be concluded that the flux is a somewhat more complicated mixture. If the aluminium to be welded is only of moderate thickness the flux may be applied with a brush in a semi-fluid paste form. For heavier work it is more convenient to dust the flux as a dry powder along the joint to be made.

The joint thus produced is free from any foreign metal. This is of great importance for the durability of an aluminium article in water. Pure aluminium is durable in sea-water, and so are joints made by autogenous welding, as has been shown by tests extended over several months. The purity of the aluminium is therefore of great importance. An easy test to determine whether an aluminium joint contains foreign metals or not is to suspend the article in water containing some hydrochloric acid. If there is any foreign metal present a galvanic couple is established and gas bubbles appear at the joint. Of course, such a joint will not last.

The mechanical properties of autogenously welded joints of aluminium are very good, as has already been noticed in our columns. Examined under the microscope the structure of the joint is found to be the same as that of aluminium itself.

In another recent issue of the *Chemiker Zeitung*, Mr. W. C. Heraeus, of Hanau, mentions another process of his own for welding aluminium, various pieces of apparatus with welded joints having been exhibited at the Paris Exposition in 1900. He has made several pressure pots of some 400 gallons capacity out of 15-millimeter aluminium sheet welded together by his process, which have successfully withstood a pressure of 17 atmospheres.

It will be remembered from the simple experiment which Mr. Schoop showed at the Chemists' Club that the application of the process is exceedingly simple, so that it should be useful not only for welding aluminium wires for electrical purposes, but for making various aluminium apparatus, tubes, pipe, etc., for chemical works, breweries, vessels, automobiles, etc.

The Dependence of Civilization on Chemistry.

Mr. Arthur D. Little, chemical engineer, of Boston, has just been re-elected official chemist of the American Paper and Pulp Association, at the recent meeting of which he read a most interesting paper upon recent development in the manufacture of paper and pulp.

From another recent paper of Mr. Little we extract the following remarks on the dependence of our civilization on chemistry:

"Chemistry enters so intimately, even though unobtrusively, into every phase of modern life and thought that it is perhaps impossible to present in any adequate degree the real dependence of the community upon the work of chemists past and present. Industrial revolutions are seldom chronicled, and more rarely celebrated, though their influence upon the welfare of mankind may be as profound as that of other revolutions, the records of which are traced in blood. It can be no longer said, as was said to the father of chemistry as he passed out to execution, 'The public has no need of chemists.' If we were to take away what chemists have contributed, the whole structure of modern society would break down at once. Every commercial transaction in the civilized world is based upon the chemist's certificate as to the fineness of the gold which forms our ultimate measure of values. Faith may remove mountains, but modern society relies on dynamite. Without explosives our great engineering works must cease, and the Panama Canal, no less than modern warfare, become impossible.

"Prices rise and fall with the variations in the gold supply as the barometer responds to the changing pressure of the atmosphere, so that to the cyanide and chlorination processes which have so greatly increased the world's supply of gold, must be ascribed a potent influence on market prices everywhere. With the development of the steel industry have come great fortunes and greater corporations, bringing with them social benefits and social problems hitherto unknown. This industry rests pre-eminently upon the work of chemists, as its greatest master has been quick to testify, and is to-day at every point under the strictest chemical control. The Bes-

semer process alone was estimated by Abraham S. Hewitt to add directly and indirectly \$2,000,000,000 yearly to the world's wealth. Of this vast sum Bessemer himself retained in all about \$10,000,000 dollars, or one-half of 1 per cent of his contribution to the community in a single year. And this is characteristic generally of the rewards which come to chemists. They are not taken from the common fund, no man is poorer for them, their recipient has made others richer in those rare cases in which he has become rich himself."

Detinning Suit.

Before Hon. James E. Howell, vice-chancellor, the suit in equity brought by the firm of Th. Goldschmidt, of Essen, Germany, against the Vulcan Detinning Co. was continued on Feb. 24 and the following days. As noticed before in these columns, the complainants ask the court to restrain the Vulcan Detinning Co. from using Dr. Hans Goldschmidt's process of detinning and for an accounting. (Concerning the history of the whole complicated litigation on electrolytic detinning, see our Vol. IV., p. 46; our Vol. V., p. 345, and this year's January issue, p. 225.)

The first witness was Mr. Samuel R. Beardsley, president of the Vulcan Detinning Co., who testified that in 1898 he and his associates sent A. Kern, of A. Kern & Co., to Europe to buy the secret process of detinning, and that Kern went abroad and purchased it from Laernos (the detinning plant in Vliessingen, Holland), who subsequently came to the United States, and with the aid of one Zeyen (formerly in the employ of Th. Goldschmidt, and now in the employ of the Vulcan Detinning Co.) constructed the detinning plants at Sewarren, N. J., and Streator, Ill., now operated by the Vulcan Detinning Co.

The complainants, Th. Goldschmidt, of Essen, claim that Kern, when he purchased the process from Laernos, knew that the process had been stolen from them (Goldschmidt) in the way described in Vice-Chancellor Bergen's former decision, abstracted at length in our Vol. IV., p. 46.

Considerable testimony was taken before the court as to the process, but this was taken in secret, so that the process itself will not be disclosed to the public. The firm of Th. Goldschmidt is represented in court by Mr. R. V. Lindabury and Mr. Halsey M. Barrett, of the New Jersey bar, and Mr. Hubert E. Rogers, of the New York bar. The Vulcan Detinning Co. is represented by Mr. Robert H. McCarter, of the New Jersey bar, and Mr. Henry Wollman, of the New York bar. The case is not yet concluded.

In this connection it may be interesting to note that the firm of Th. Goldschmidt intend to shortly begin detinning in this country.

CORRESPONDENCE

The Removal of Sulphur in the Electric Induction Furnace.

To the Editor of *Electrochemical and Metallurgical Industry*:

SIR:—With respect to the note on Mr. A. Schmid's article on the removal of sulphur in the electric induction furnace (your February issue, p. 81), I beg to make the following remarks:

I have found considerable reaction on heating sulphides and silicides together. When iron, containing a high content of sulphur and silicon, is heated to the high temperature existing in electric furnaces, the silicon and sulphur react. Gaseous (at that temperature) silicon sulphide is evolved. It can be easily caught and identified as such or can be absorbed by having calcium silicide in contact with the electrically heated iron. This calcium silicide, when cold, liberates sulphuretted hydrogen in contact with water.

MAX HAFF.

OTTAWA, CAN.

Electric-Furnace Reactions Under High Pressure.

An account of a very extended investigation by Dr. R. S. HUTTON and Mr. J. E. PETAVEL, on electric-furnace reactions under high gaseous pressures, was presented in a paper last year before the Royal Society of London. The full account may be found in the Philosophical Transactions of this Society, series A. Vol. 207, pp. 421 to 462 (A. 423, Jan. 17, 1908).

High-Pressure Furnace.

The authors first give a full account of their high-pressure furnace (which was already briefly noticed and illustrated

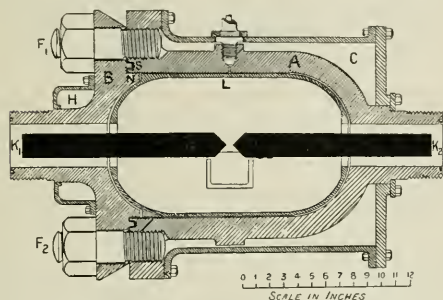


FIG. 1.—SECTIONAL DRAWING OF HIGH-PRESSURE FURNACE.

in our Vol. I, p. 244). It is capable of employment as resistance or arc furnace in various ways and may be used to pressures as high as 200 atmospheres. A large steel enclosure of about 20 liters capacity was designed, so that within the shell many different forms of furnace, such as arc or resistance furnaces, could be built up. The furnace may be used either in a horizontal or vertical position to suit different requirements.

The construction of the enclosure will be easily understood by reference to Figs. 1 and 2, giving sectional drawings. The shape of the interior is cylindrical, 10 inches diameter by 17 inches long, with hemispherical ends, one of which forms the cover B, and is held in place by ten $2\frac{1}{2}$ -inch studs (F_1F_2), which are fixed into a flange of the main forging A. The cover is rendered gas-tight by a spigot joint S, packed with lead; it is surmounted by a cast-iron casing H, through which cooling water is circulated.

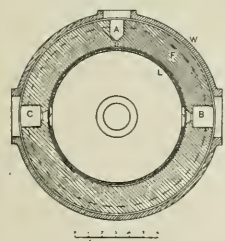


FIG. 2.—TRANSVERSE SECTION THROUGH THE CENTER OF HIGH-PRESSURE FURNACE.

from contact with the hot gases when the furnace is in use and shields it from mechanical injury when the cover is being lifted or replaced.

Both the horizontal ends of the furnace have projections K_1K_2 bored out to a distance of 3 inches. The carbon holders which move in these recesses are thus protected from the direct heat or flame of the furnace. The length of the projections K_1K_2 is sufficient to allow a feed of 8 inches. To obviate any risk of damage to the main forging by contact with

the hot furnace materials, a cast-iron lining L was always used.

When in a horizontal position the furnace rests on four cast-iron feet, as shown in Fig. 3. When vertical (Fig. 4) it is supported by the cover of the water jacket the lower carbon feeder passing through a hole cut in a massive wooden stand.

The main forging is provided with three openings, as shown in Fig. 2, which is a section through the center of the furnace perpendicular to the axis of the carbons.

The aperture A serves to receive the valve through which the enclosure is filled with compressed gas, whereas in most cases one of the windows shown in Fig. 4 is screwed into B. The third opening is connected to a pressure gauge, and serves, also, when desired, for the escape of the gaseous products of reaction. W is the water jacket, F the main forging and L the cast-iron lining.

The carbon-feeding mechanism is shown in detail in Fig. 5. A ring B is fitted to each of the projections K of the furnace. To this ring the small cover A is bolted. The joint is made, as in the case of the main furnace cover, by means of the lead-packed spigot V. The cover carries two columns C_1C_2 surmounted by a yoke Y, which is insulated from them by micantite bushes and washers R. To this yoke the main terminals (not shown in the figure) are fixed. The nut N is

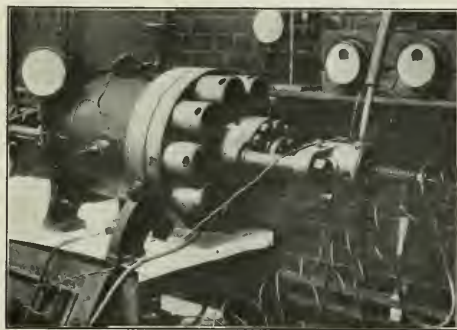


FIG. 3.—HIGH-PRESSURE FURNACE (HORIZONTAL POSITION).

revolved by means of steel levers inserted in the holes T, and thus the feeding rod S is moved forward. The feather F fits in a groove cut in this rod and prevents it following the rotary motion of the nut.

The feeding rod passes into the furnace through the insulated stuffing-box P. This stuffing-box serves the double purpose of making a gas-tight joint and providing insulation sufficiently perfect for the relatively low e. m. f. which is generally required with this furnace. As packing a mixture of asbestos and tallow is used, which in itself assists the insulation. The stuffing-box is compressed by means of the ring D, which presses on the gland Q, but is electrically insulated from it by mica washers and bushes. The inner gland is insulated in a similar manner from the steel cover.

The feeding rod is hollow. The current of water passes into it at I, and flowing through an inner brass tube is delivered at the extremity of the rod and passes back to the outlet O. A gas connection G is also provided, by means of which compressed gas can, when necessary, be passed directly into the center of the furnace through the axis of a hollow electrode M.

Two different patterns of carbon holders are used by the authors. Carbons of 30 millimeters diameter or less are held by clamps. The larger carbons are electro-coppered at their ends, and soldered into cup-shaped holders, as shown at H (Fig. 5). The lip of the cup is fitted with a ring of refractory insulating material U, which nearly fits the bore of the

tube K, and thus protects the stuffing-box from flame and dust.

Although unnecessary for the purely chemical work, it may be desired to observe or photograph the arc or its spectrum under conditions of high pressure. For this purpose windows are inserted in the openings P and C of Fig. 2.

The forms of construction are shown in Fig. 6. The window itself consists of a glass or quartz cone W, $\frac{3}{4}$ inch thick and $\frac{1}{2}$ inch diameter at its smaller end. This transparent cone is forced into the gunmetal fitting after being surrounded with a thin film of cement, and is held in place by a metal ring, the shape of the glass tending to make the joint more perfect the higher the pressure.

The joint between the fitting and the aperture in the main forging is made by the ring *a* turned on the end of the fitting, which presses tightly against a steel ledge, no packing being required. The joint between the fitting and the water jacket is made by means of a gunmetal ring R, which screws onto the fitting itself.

The two types of window differ only in the relative position

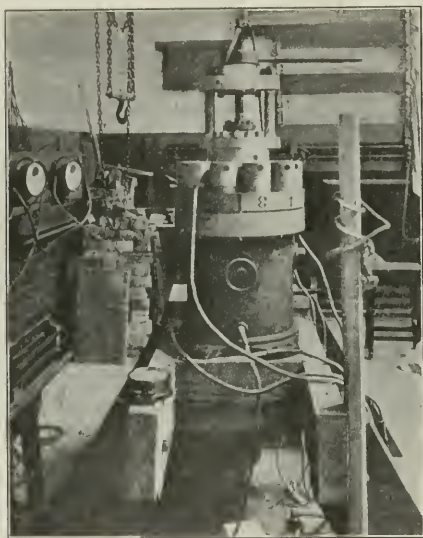


FIG. 4.—HIGH-PRESSURE FURNACE (VERTICAL POSITION).

of the transparent plug. The design shown at A gives a clearer view of the arc, but for very large currents it is advisable to make use of the fitting B, in which the glass plug is more carefully protected from the source of heat.

Throughout the work no difficulty has been experienced in keeping the furnace gas tight. It is of course, equally suitable for use as a vacuum furnace and has been occasionally employed in this way, in connection, for instance, with spectroscopic investigations.

For high-tension currents up to 25,000 volts, the authors employed a smaller furnace, for the description of which the readers must be referred to the complete paper. As to the preparation, a compression of gases, reference should be had to the authors' former paper in our Vol. II, p. 139.

The Behavior of the Electric Arc Under Pressures.

When the arc is started in a compressed oxidizing atmosphere, the current is at first unsteady and the electrodes must be rapidly fed up. Soon, however, a steadier state is reached. If, after such a run, the furnace is opened and the carbons examined, it will be observed that by the action of the current the electrodes have been so shaped as to nest one into the

other. In this way a considerable cross-sectional area is produced, over which the discharge can occur.

The c. m. f. of the arc rises as the presence of the surrounding atmosphere increases, and at the high pressures used in the course of this work it becomes more than double the normal value. It is, however, the first few atmospheres which produce the greatest effect upon the voltage.

An interesting effect is throughout noticeable. Although the

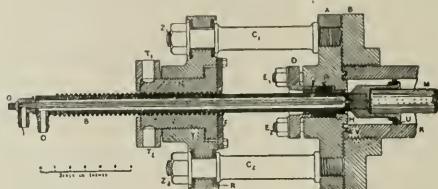


FIG. 5.—CARBON-FEEDING MECHANISM.

maximum length of arc is so much reduced, the voltage is in all cases abnormally high, and consequently a large amount of power is concentrated in a small space.

Two very distinct types of arc exist. The most usual in these enclosed furnaces is found with a non-oxidizing atmosphere, such as carbon monoxide or nitrogen. In such arcs at ordinary current densities the electrical conditions are complicated by the rapid growth of a deposit of carbon, chiefly around the negative electrode and often completely enclosing the end of the positive electrode. The difference between a resistance and an arc is then less marked. The arc flame is not visible, but is replaced by a zone of brightly incandescent carbon; electrically the conditions are ill-defined and difficult to reproduce. With an exceptionally high current density the arc in a non-oxidizing gas at high pressure gives a well-defined flame.

An entirely different type is obtained in an oxidizing atmosphere, and in this case alone are the results comparable with the well-known conditions of the ordinary open arc. The arc

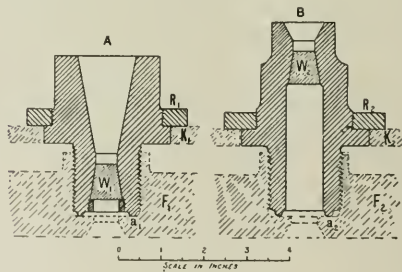


FIG. 6.—WINDOWS.

then shows a bright flame, which, if the electrodes are fed up rapidly and with regularity, can be easily maintained. Here again the increased voltage observed is due principally, as shown by other experiments, to the first 10 or 15 atmospheres.

A noticeable feature in all the experiments carried out in air is the very rapid rate of burning of the electrodes.

To take one instance: with 27 millimeter carbons and a 30-amp. arc under a pressure of 29 atmospheres the carbon was consumed at a rate of about 6 millimeters per minute, which is nearly twenty times as fast as at ordinary pressures. This burning is principally limited to the positive electrode. With very high-current densities the combustion becomes very violent. The oxygen thus becomes rapidly exhausted and the subsequent feeding required is relatively very small.

At first carbonic acid is formed, which is in turn reduced to carbon monoxide. This reduction occurs also when the arc is run in an atmosphere of compressed carbonic acid. In the latter case an interesting observation is the separation of flocculent carbon, which is seen to be moving rapidly in the convection currents. This phenomenon is observed from the commencement of the experiment.

The decomposition of the carbonic acid under these conditions is comparatively slow, in one experiment less than half being decomposed by the end of half an hour. A somewhat similar process goes on also in non-oxidizing gases. Finely divided carbon is deposited in considerable quantities on the cool walls of the enclosure, the weight collected being in fair agreement with the loss from the electrodes. With such gases the atmosphere, however, remains perfectly clear.

Different High-Pressure Reactions.

The first application of their furnace, made by Messrs. Hutton and Petavel, has been the investigation of the effect of high gaseous pressure upon the more characteristic and better-known electric furnace reactions. The first reaction investigated by them is the formation of **calcium carbide**. For this purpose the furnace is used in a vertical position, a layer of powdered retort carbon on the bottom of the furnace constituting the lower electrode. A mixture of lime and carbon (about 10 kg.) is filled up around a paper tube, which serves to keep a central passage free for the upper electrode. After closing the furnace the arc is started by lowering the upper electrode, which then makes contact with a carbon bed beneath it. The reaction then starts.

As it proceeds, the pressure in the furnace, due to the evolution of carbon monoxide, rises rapidly and the fused carbide collects upon the bed of carbon and soon accumulates sufficiently to come in contact with the end of the electrode. The sharp drop of the e. m. f. thus produced serves to indicate that the time has arrived to raise the carbon slightly. There is no difficulty in maintaining the smothered arc even at the highest pressures, and the regulation of the power is quite a simple matter. Currents of some 500 amps. have frequently been employed in the course of this work and maintained as long as desired.

While with ordinary atmospheric pressure the upward rush of the gases through the finely divided charge is liable to cause a considerable displacement of the charge, this is not the case at high pressures, since the gaseous products of reaction rise at a relatively slow speed and percolate through the mixture without disturbing it. On the other hand, if the furnace is used as a vacuum furnace, the projection of the charge is very marked and causes considerable trouble.

An extremely low consumption of the carbon electrodes is characteristic of the high-pressure process, the consumption being so small as to be hardly appreciable.

The authors have carried out a long series of experiments, especially to study effect of carbon monoxide upon the yield. They conclude that, "however contradictory it may seem, even a concentrated and compressed atmosphere of carbon monoxide has no deleterious effect upon the formation of calcium carbide. The influence of pressure *per se* has not resulted in any marked change in the chemical or physical nature of the products, neither can a considerable decrease in the yield be traced to this cause. Such variations in the purity or richness of the carbide as have been noticed are attributable only indirectly to pressure, being accounted for by the increased thermal losses in high-pressure gases."

The next process to which the authors have employed their high-pressure furnace is the **fusion of silica**, in the hope to obtain a greater fluidity of the silica, resulting in freedom of the final product from occluded gas bubbles. However, these experiments though they have been modified in various directions, have not resulted in the production of transparent fused quartz free from bubbles.

The authors have then studied the formation of **carborundum** under high pressure, the pressure being allowed to rise up to 100 atmospheres.

"There is little doubt that the production of carborundum is the result of the interaction of the vapor of silica and the highly-heated granular carbon. From the previous work on quartz we were therefore led to anticipate that under pressure the reaction would not occur very rapidly.

"Several experiments confirmed this impression. An examination of the furnace after the run showed, in every case, that, though the mixture of sand and carbon had attained a sufficiently high temperature to effect the fusion of the quartz to a considerable depth, thus agglomerating the mixture, only a small quantity of carborundum was formed, and that immediately around the central core.

"Another distinctive feature of the pressure experiments is the almost entire absence of the amorphous variety of carborundum. The reaction progresses at a slow rate, but apparently uniformly, the resulting pressure being, as in the case of calcium carbide, a linear function of the time."

The last investigation of the authors refers to the **direct reduction of alumina by carbon**. Since a successful solution of this problem would be of great importance we give this part of the paper in full elsewhere in this issue.

The whole investigation was carried out with the aid of funds awarded by the Government Grant Committee of the (London) Royal Society, in the Physical Laboratory of Manchester University.

A Review of the Zinc Industry.

By H. M. BURKEY.

The zinc industry during the year 1907 kept abreast with business in general. The smelting capacity was increased by the completion of several new plants, the construction of which was started either in 1906 or early in 1907, when there was a fair margin between the price of the ore and that of spelter.

In the last quarter of 1907, the general falling off in business also reflected on the zinc industry. The drop in the price of spelter caused many mines with high cost of operations to shut down, resulting in a scarcity of ore, which, combined with the low price for spelter, made smelting unprofitable, so that many furnaces were put on dead fire or shut down altogether.

At present, the state of the zinc industry is briefly as follows:—

ORES.

The problem of milling complex sulphides with a high recovery of the zinc content, as well as of the other metallic constituents, still presents a problem for a satisfactory solution. The present method of smelting requires a comparatively pure material to work on. It must not contain impurities to contaminate the spelter nor substances that will attack the retorts. Besides, if the ore be a sulphide, it must be roasted to a low sulphur content so as not to hold back too much zinc in the smelting operation. To avoid these difficulties in milling, there is at present a tendency to develop processes which will treat sulphides directly for the recovery of all metals contained therein, or after they have been roasted to about 5 per cent sulphur. Such processes as Imbert's and Rice's may be mentioned to illustrate the former and those of Snyder and Johnson the latter method. The advantages from such a process, if commercially successful, are many, and it is therefore not surprising that many efforts are bent in this direction.

Magnetic separation, either of the crude or of the partly roasted sulphides, still holds its position in the milling of zinc ores.

The best-known electro-magnetic separators are the Wetherill, the Dings, the Cleveland-Knowles and the International.

Of these, only the Wetherill is used for the separation of

crude sulphides. No other commercial machine has made its appearance during the year. Of the electro-static separators, the Blake-Morscher machine is the only one used in this country. At the Colorado Zinc Company, supplementary to the Wetherill, it separates resin blende, which is non-magnetic, from pyrites. An electrostatic machine of a different make is said to be used successfully in Mexico. For giving an ore containing blende and pyrites a magnetic roast, to make the pyrites magnetic, A. R. Willley (United States Patent No. 859,420 of July 9, 1907, *ELECTROCHEM. & MET. IND.*, vol. V., p. 330) has designed a furnace wherein the ores travel downward with a current of combustion gases and air. At the bottom of the furnace they come in contact with a water-cooled plate whereby they are cooled to a temperature below that of roasting, and then carried out of the furnace. This type of furnace has been installed by the Summit Mining & Smelting Co., at Kokomo, Colorado, the Colorado Zinc Co. at Denver, and the Empire Zinc Co. at Canon City, Colorado.

A series of experiments was, in 1897, carried on by Dr. F. Esser ("Metallurgie," 1907, p. 592 and p. 607; *ELECTROCHEM. & MET. IND.*, vol. V., p. 466), on mixtures of blende and other minerals on an electric separator. The results obtained show that electrific separation is only successful on particles within certain sizes. Particles of 1 mm. or less gave the best results. A very fine powder was not suitable. Impregnation of foreign material acts as a disturbing factor and conditions are more favorable at places high above the sea level, which, as a rule, have a dry climate.

Much had been said about the flotation processes in the past, but of late little is heard of them. Experimentally, they proved very efficient but their success on a commercial scale is not so evident. During the year, the following three new flotation processes have received attention:

The Elmore Vacuum Oil Process depends, not only on the oil and acid added to give buoyancy to the metallic particles, but also on the air in the water drawn out by the vacuum. This process is carried out in a machine which is automatic and continuous and the consumption of acid and oil as well as the power required is said to be low. On Broken Hill tailings over 95 per cent of the zinc content has been extracted.

D. Norris (United States Patent 864,856 of Sept. 3, 1907 and 873,586 of Dec. 10, 1907) points to the fact that at high altitudes water does not contain enough air to float the particles in the vacuum process and he, therefore, proposes to supply air under pressure. This process has not yet been tried on a working scale.

The tube process of Macquisten (United States Patent No. 805,194 of Sept. 3, 1907, and 865,195 of Sept. 3, 1907) works on a different principle from the other flotation processes, as it does not use any oil or acid. It relies on the fact that sulphides do not penetrate the thin film on the surface of water, while the gangue does. This process is also automatic and continuous. At the Atlantic Cable Mine, Rico, Colorado, a concentrate containing 7.78 per cent Pb. and 41.2 per cent Zn. was made from an ore assaying 3.94 per cent Pb. and 10.19 per cent Zn. (*ENG. & MIN. JOUR.*, October 26, 1907).

ROASTING.

Of the mechanical reverberatory kilns the Zellweger is now the favorite, while the Hegeler type of roasting furnace is used where the gas is to be converted into sulphuric acid. The Pennsylvania Salt Manufacturing Co. has put the Wedge furnace, a McDougal type, on the market. The large sizes in which this roaster is made and the large-sized central shaft which allows a man to enter, making thus all parts of the furnace accessible, are a decided advantage. During the year, quite a little attention was given to the cooling arrangement of shafts and arms as well as to a removable rabble, as is shown by the following United States Patents:

Klepcko, No. 843,825 of February 12, 1907;

Rankin, No. 863,045 of August 13, 1907;

Kirk, No. 863,187 of August 13, 1907;

Leggo, No. 872,827 of December 3, 1907, and

Shipley, No. 873,687 of December 10, 1907.

SMELTING.

Of the patents granted on furnaces, the following may be mentioned: Lanyon (United States Patent 839,100 of Dec. 25, 1906; *ELECTROCHEM. & MET. IND.*, vol. V., p. 64) arranges his furnace so as to give a gradual and perfect combustion of the fuel. Fuel and air are admitted at the bottom of the furnace where ignition starts, the hot gases pass upwards around the retorts, meeting more air of combustion from openings in the sides, then strike the arch of the roof, thereby being deflected downwards, and pass out through openings in the bottom. This arrangement makes possible a very perfect combustion, which is easily regulated.

A. Desgraz and P. Schmidt (United States Patent 843,872 of Feb. 2, 1907; *ELECTROCHEM. & MET. IND.*, vol. V., p. 97) aim to obtain in a distillation furnace a uniform temperature throughout the furnace in the heating from the initial temperature to that required at the end by placing rows of retorts on each side of a combustion chamber into which gas and air are admitted through ports in the bottom. The supply of gas and air can be regulated from the outside to give the desired results.

A lining for retorts composed of two layers is made, according to F. B. Smith and G. C. Glynn (United States Patent No. 866,701 of July 23, 1907) from two coats applied to the inside of the retort. The first solution is one of aluminium and magnesium sulphates, into which an easily fusible compound of an alkaline earth metal, such as calcium fluoride, has been thoroughly mixed. The second coat is made by mixing carborundum in a solution of chromic acid. The action on application of heat is said to be as follows: Aluminium and magnesium sulphates break down to their oxides, the sulphuric acid set free combines with the calcium fluoride, forming an enamel which is claimed to become very hard. Results recently obtained on Joplin ores show a saving in retort fuel and a higher recovery in spelter over the ordinary method (private communication).

For obtaining the intimately mixed charge of ore and reducing carbon, so necessary for good results, concrete mixers, such as the Ransone, are being used. A Vapart mill is used by the Bartlesville Zinc Co., the United Zinc & Chemical Co. and the United States Zinc Co. at Pueblo, for this purpose.

James (United States Patent No. 851,668 of April 30, 1907) and Kirk (United States Patent 847,074 of May 18, 1907) have invented devices for mechanical charging of retorts. They both use the same principle, viz.: the injector-like action of a jet of a medium under pressure. This medium can be either steam or air.

For making claya condensers, the newer smelters have installed the Vanatta machine (United States Patent 832,177 of October 2, 1906).

Special processes which have been brought out recently are those of De Laval, Imbert and Rice.

De Laval (United States Patent 852,440 of May 7, 1907; *ELECTROCHEM. & MET. IND.*, vol. V., p. 241, where the furnace is illustrated), subjects the ore and reducing material to a rapidly rotating gas or air current in a vertical cylindrical furnace and the chemical reactions occur in the rotating mass. Slag and unreduced ore stay near the sides of the furnace and are collected and drawn off at the bottom, the gases and vapor escape through a central opening in the bottom to a condenser. When a sulphide ore is being reduced, the charge will consist of ore, iron ore and carbon, the gas, CO or the proper amount of air to form CO gas; when oxides are used, carbon is only added, and the gas may be either CO or air; and when zinc oxide is to be produced, carbon is added and air is blown in. The large amount of gas that would have to be used is a feature that does not argue well for the process, because the

resulting vapor would necessarily be diluted to a great extent and blue powder or zinc dust is likely to result instead of metallic zinc.

What is known as the "Precipitation Process" forms the subject of Imbert's inventions (United States Patents Nos. 875,578, 875,579 and 875,580 of December 31, 1907). The ores, which can be either sulphides or oxidized ores, are dissolved in a fused bath, to which a metallic reagent, such as iron or copper, is added, thus precipitating the zinc as vapor and lead, if present, as metallic lead. The solution for sulphides may consist of a metallic oxide and metallic earth oxide or a metallic oxide and metallic sulphide, while for oxidized ores it will be a fused bath of metallic oxide and a metallic sulphide.

Rice's process (United States Patent No. 875,381 of December 31, 1907) also belongs to this class. Crushed sulphide ore mixed with about 50 per cent of finely divided iron is heated in a crucible. The volatilizing metals pass to a series of condensers and are recovered separately by regulating the temperature of the condensers. Non-volatile metals remain in the crucible in form of a matte.

THERMOELECTRIC SMELTING.

The thermoelectric smelting of zinc ores offers great possibilities. The processes can generally be made continuous and produce gases rich in zinc vapor. However, cheap electrical power must be at the disposal of the smelter, and besides many difficulties must be overcome. One of these is the condensation of large quantities of vapor to metallic zinc and not to zinc dust. Johnson (United States Patent No. 851,520 of April 25, 1907) has designed a condenser to overcome this difficulty. It is constructed of refractory material provided with baffle walls, thus giving the gases a tortuous path and a water-cooled metallic plate bottom protected from the action of the gas by a layer of molten zinc.

Johnson (United States Patent No. 868,345 of October 15, 1907; *ELECTROCHEM. & MET. IND.*, vol. V., p. 470) proposes to smelt ores with a high iron contents by first roasting to zinc oxide and iron oxide, leaving about 3 per cent S. in the ores, mixing with reducing coal, heating in an electric resistance furnace to about 900 deg. C., thereby reducing the iron oxide to iron sponge continuing the heating until a temperature of about 1,100 deg. C. is reached, when the zinc oxide is reduced and the iron reduces any sulphide of zinc, lead and copper present. The advantages claimed are that the roaster gases, richer in sulphur, are produced and less electrical energy is consumed by bringing about the reduction of iron and zinc in successive steps; besides, the zinc vapor is not diluted.

Other electric processes are those of:

Taylor, United States Patent No. 843,777 and 843,776, of February 12, 1907; Petersson, United States Patent No. 858,621 and 858,622, of July 2, 1907; Snyder, United States Patent No. 859,132, 859,133, 859,134, 859,135, 859,136 and 859,137, of July 2, 1907; and McLoughlin, United States Patent No. 874,527, of December 24, 1907. See *ELECTROCHEM. & MET. IND.*, vol. V., pp. 103, 228 (Taylor), p. 377 (Petersson) and p. 323 (Snyder).

Of these, it is known that Snyder has been experimenting for some time at Vancouver, B. C. (Report of Commission to Investigate Zinc Resources of British Columbia), and a furnace having a capacity of 10 tons has been built at Nelson, B. C. (*Mineral Industry* for 1906.) Also that the Canadian Zinc Company will start electric smelting in February of this year. (*Mining and Scientific Press*, of January 11, 1908.) In a paper recently read before the Tristate Mining Association (*ELECTROCHEM. & MET. IND.*, vol. V., p. 480), Snyder claims a total saving of \$10.00 per ton over the retort plant.

LIXIVIATION.

Many attempts have been made to treat complexed ores by dissolving them in solutions, then recovering the metals by depositing some other metal or by the electric current. The

main object is to get the ore in solution and for its accomplishment United States Letters Patents have been granted to Baker and Burwell (No. 841,102 of January 3, 1907); Baker and Smith (No. 843,986 of February 12, 1907); Fronck (840,868 of March 5, 1907); Angell (No. 851,639 of April 30, 1907); MacIvor (No. 863,411 of August 13, 1907) and Gilles (No. 875,424 and 875,425 of December 31, 1907), and others. An account of Baker's endeavors in this field is given in an American Electro-chemical Society paper (*ELECTROCHEM. & MET. IND.*, vol. V., p. 448).

A process for utilizing zinc sal-ammoniac skimming from the galvanizing industry has been invented by B. Terne (United States Patent No. 869,750 of October 29th, 1907). The skimmings are ground under hot water, the insoluble matter treated for metallic zinc, and the solution for zinc oxide and sal-ammoniac. This process has been worked on a practical scale.

ZINC OXIDE.

To overcome the injurious effects of the volatile matter of bituminous coal in the Wetherill process of manufacturing zinc white and at the same time make use of an ore containing lead, W. F. Gordon (*Eng. & Min. Jour.*, Jan. 5, 1907, p. 1032), has developed a process which is in practical use at Coffeyville, Kan. The ores, after roasting, are burned in a furnace similar to the Wetherill, the zinc and lead are volatilized, the former is recovered as oxide, while the lead combines with sulphur, enough being left in the ore for this purpose, forming a basic lead sulphate.

The Tri-Bullion Smelting and Refining Company are said to have prepared plans for a large pigment plant near Canon City, Colorado, to treat the lead-zinc ores from the Kelly Mines of New Mexico.

An electrolytic process of making lithopone has been invented by J. B. Candau and A. Candau (United States Patent No. 868,253 of Oct. 15, 1907; *ELECTROCHEM. & MET. IND.*, vol. V., p. 471). Briefly, it is as follows: Barium sulphide is produced from barium sulphate by electrolysis, as is also zinc sulphate from metallic zinc. By mixing the two solutions lithopone is produced. The advantages claimed for this process are that a very white pigment is made and that metallic zinc waste can be used without purifying the resulting salt.

GALVANIZING.

During the year the process of "Sherardizing" or "Dry Galvanizing" has been introduced into this country. Articles to be coated, after cleaning in the usual way, are placed in blue powder or zinc dust in an air-tight iron cylinder, which is then heated to 300 deg. C. or more. The articles when taken out are covered with a layer of zinc, which seems to have alloyed with the other metal. The United States Dry Galvanizing Co., which has been formed to exploit this process, has a small demonstrating plant in operation. A larger plant is in course of erection in New Jersey.

A device for electric-plating small as well as large articles is the invention of L. Potthoff, president of the United States Electro-Galvanizing Co. (United States Patent 866,959 of Sept. 24th, 1907; *ELECTROCHEM. & MET. IND.*, vol. V., p. 331). This apparatus has been in practical use and is said to give good results.

Contributions to the literature of zinc have not been wanting and attention is called to the following articles and papers:

Ueber den Flotation Process, C. Goepner, "Metallurgie," 1907, p. 522-543.

Acid Flotation Process, F. H. Jackson, "Min. & Scient. Press," 1907, 6-8.

Gattierung von Zinkblende und Galmey, J. Juretzka, "Metallurgie," 1907, p. 84.

"Studien ueber das Verhalten von Eisen Oxyden zu Zinkblende," C. H. Graumann, "Metallurgie," 1907, p. 60.

"Versuche ueber die Reduktion von Zinkoxyd," F. O. Doeltz and C. H. Graumann, "Metallurgie," 1907, p. 290.

"Physical Factors in the Metallurgical Reduction of Zinc Oxide," W. MacJohnson, in the "Bi-monthly Bulletin of the Am. Inst. of Mining Eng., No. 17, 1907, and ELECTROCHEM. & MET. INDUSTRY, vol. V., p. 498.

"The Electrometallurgy of Zinc and its Relation to Recent Practice," two papers, by W. MacJohnson, the first in ELECTROCHEM. & MET. IND., vol. V., p. 83, the second in *Trans. Am. Electrochem. Soc.*, 1907.

"Electro Deposition of Zinc," R. S. Snowdon. *Trans. Am. Electrochem. Soc.*, 1907.

"The Electro Metallurgy of Zinc," Gustav Gin, paper read before the Electrochem. Society.

"Theory and Practice of Sherardizing," Alfred Lang, "Electrochem. & Met. Ind.," 1907, p. 187; "Iron Age," 1907, vol. 79, pp. 1554, 1640.

"Report of the Sub-Committee on Zinc Ore Analysis," by Geo. C. Stone and W. C. Waring.

"Die Untersuchungs-Methode des Zinks unter besonderer Berücksichtigung der technisch-wichtigen Zinkerze," H. Nissen-sen.

From the foregoing it will be seen that the old retort process is still being improved. The treatment of complexed sulphides seems, however, to have received the greatest attention. The thermo-electric processes may finally offer a satisfactory solution, especially where cheap water power is to be had and coal difficult to get. However, many difficulties must still be overcome and, besides, improvements in the present practice are still possible, opening a wide field to the inventive mind.

Purification of Gases.

By OSKAR NAGEL, PH. D.

Separation of Gases from Solids.

The removal of dust from gases is quite an important metallurgical and chemical problem, which can be solved in different ways. In all the processes used for this purpose, however, it is necessary to cool the gas before separation can be effected. In some cases a simple cooling by means of

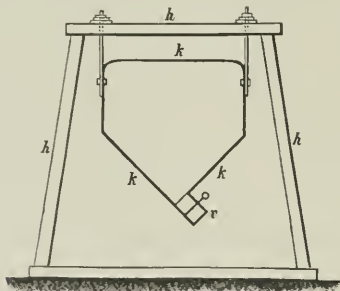


FIG. 1.—COOLING APPARATUS.

certain appliances is sufficient to remove the dust nearly completely. Such a gas or air-cooling apparatus is shown in Fig. 1. It consists of a sheet-iron channel *k*. The dust collects upon the bottom of same and is removed through openings *r* provided in certain distances. The friction of the gas current with the walls of the channel facilitates the separation.

Filtration is frequently employed for collecting dust which is contained in gases in a finely-divided state. In the manufacture of zinc oxide, for instance, the air containing the oxide is filtered through bags in which the solid particles are retained.

A decrease of the velocity of the gas current also facilitates the separation. For this purpose the gases are led into chambers or channels before they are allowed to escape

through the stack. As decrease of draft is not nearly as effective as frequent and continued contact with large surfaces, narrow channels are more advantageous than large chambers.

Another way of causing separation is the change of the direction of the gas current, which is the more effective the cooler the gas. Zig-zag shaped channels are used for this purpose.

For removing the dust from blast-furnace gas, wet processes are almost exclusively used. In the Zscheoke system (illustrated, ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, Vol. IV., p. 396, Fig. 1) the gas is washed in scrubbers, which are so constructed that they cannot be clogged up by the dust. In the Theisen system (illustrated in ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, Vol. IV., pp. 396 and 397, Figs. 2 to 5) the gas is exposed to the action of a rapidly revolving fan into which water is injected, the removal of the dust being due to centrifugal force. An apparatus of the same class is built by the Buffalo Forge Co. A "moist" dust collector, which works very satisfactorily, is built by the Schuette & Koerting Co. in Philadelphia (Fig. 2). In this system the gas or air to be purified enters at E. The removal of the dust is effected by spray nozzles. The air leaves at A, the water containing the dust at L.

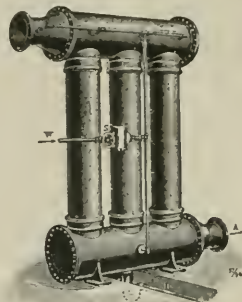


FIG. 2.—DUST COLLECTOR.

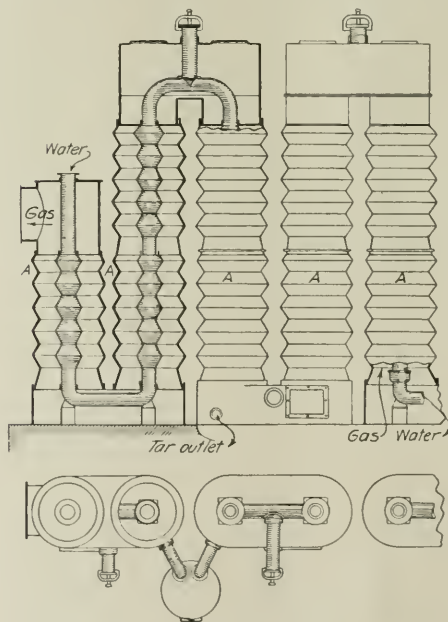


FIG. 3.—COOLER.

Separation of Gases from Liquids.

If it is desired to separate gases from liquids in which they are absorbed, the process to be applied will be different according to whether the gas liberated is to be used or wasted. In

the former case a distilling apparatus with condensing cooler will have to be used, while in the latter case an evaporating apparatus can be applied. Gases that are absorbed by liquids at high temperatures can be conveniently separated by cooling the liquid. An apparatus which is successfully used for this operation is Mohr's cooler, Fig. 3. It consists of zig-zag shaped pipes containing in the interior cooling pipes of the same shape. The pipes A are connected at the top and at the bottom by so-called connecting boxes; in the bottom boxes outlet openings are provided for the liquids separated.

The separation of gases and liquids is of considerable im-

portance in the manufacture of illuminating gas; as the apparatus used heretofore can also be used in other analogous operations occurring in the chemical and metallurgical industries, we are going to discuss the principal types.

On entering the inlet the gas ascends into the cylindrical chamber, passes through the perforations of the drum, and is divided into small jets, which strike against the solid surface sheets placed close to the perforated plates. In passing through the small perforations the liquid molecules are wire-drawn, and therefore brought into close contact with one another, the action being completed by contact with the solid surface upon which the tarry matter is deposited, whence it flows down the surface of the plate into the annular tar chamber, and from there through the overflow to the tar well.

The drum properly balanced is capable of acting as its own regulator; when there is an increased make of gas the cylinder rises, and a great number of perforations are exposed to the passage of the gas.

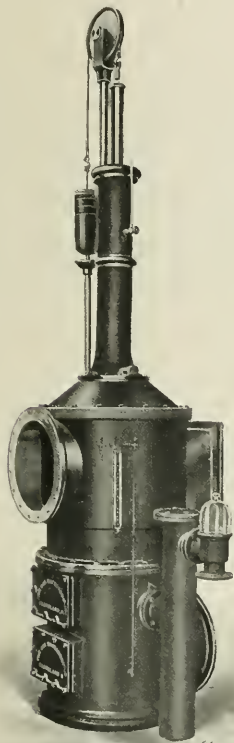


FIG. 4.—TAR EXTRACTOR.

portance in the manufacture of illuminating gas; as the apparatus used heretofore can also be used in other analogous operations occurring in the chemical and metallurgical industries, we are going to discuss the principal types.

The most widely used tar-extractors are the ones of the Pelouze and Audouin type; they are built in the United States by the Gas Machinery Co., Cleveland, Ohio. Fig. 4 shows the general view of a tar extractor, Fig. 5 the drum and Fig. 6-a cross-section.

This apparatus consists mainly of an outer cylindrical cast-iron cover, provided with inlet and outlet openings for gas and overflow, for products of condensation, and contains a drum of perforated sheet steel counterbalanced by a weight on the outside, the connection being made through a hydraulic seal on top of the apparatus. The drum constitutes the extractor proper. The inner sheet is perforated with rows of closely

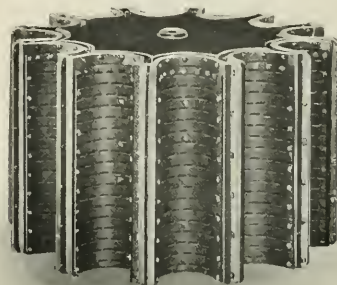


FIG. 5.—DRUM

Separation of Gases from Gases.

For separating gases from gases, in most cases the absorption process is used in practice. The gas not absorbed by the liquor used can be collected and the absorbed gas worked up separately.

If the gas mixture consists of more than two gases, as is the case, for instance, with crude coal gas, the various gases are absorbed consecutively in various vessels.

As the liquefaction of different gases depends on pressure and temperature, this property can also be used for separating gases (Gailey's process of drying the blast).

The following examples will show the most important types of apparatus used for separating gases:

An apparatus for removing and absorbing ammonia from gases, as built by the Gas Machinery Co., Cleveland, Ohio, is shown in Figs. 7 to 9. Fig. 7 shows a section through the washer parallel with ducts, Fig. 8 a cross-section of ducts in operation, and Fig. 9 a section through the washer across the ducts.

This washer consists of a rectangular cast-iron box and a top cover of sheet steel. A gas-inlet distributing box and a gas-outlet box are bolted to the outside of two side plates and provided with openings for gas inlet and outlet connections. Ducts of sheet steel, specially perforated, extend horizontally across the inside of the washer, one end of the upper circular part of the ducts connecting through round openings in the inlet side plate with the inlet distributing box, and the other end placed against round openings in the opposite side plate. The upper or outlet compartment above the ducts is connected with the gas-outlet box by means of a long horizontal opening placed near the top of the box.

The washer is allowed to fill with liquor until the depth of seal through which the gas has to force its way will show a differential pressure of about 3 inches. The overflow should be set to allow the liquor just to pass when this point is reached, the cock in the equalizing pipe being open.

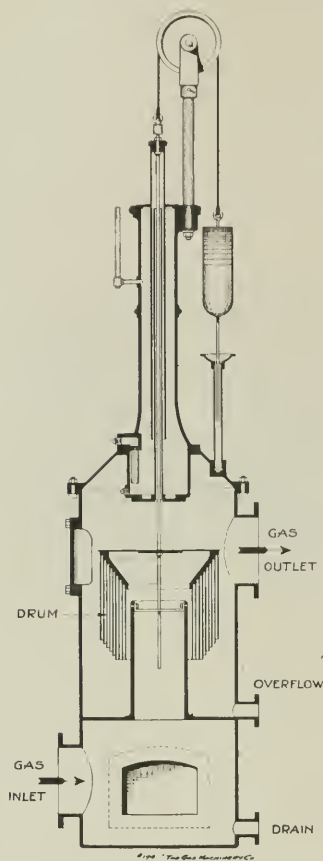


FIG. 6.—CROSS-SECTION OF TAR EXTRACTOR.

The gas first passes into the inlet distributing box and through the circular openings in the inlet side plate into the upper parts of the ducts, depressing the liquor in the narrow throat of the ducts and passing through the small holes in the slanting surface of the submerged part, thereby effecting a fine distribution of the gas, which passes up through the liquor in minute bubbles.

The gas then goes into the top of the washer and through the long horizontal opening in the outlet box.

The long horizontal outlet opening extends nearly the whole width of the box, and is made of ample area to allow for the slow and easy passage of the gas. This prevents carrying entrained water with the gas.

Of entirely different construction is the gas absorption apparatus of Schuette & Koerting, in Philadelphia. Here an extremely fine spray of water, which is produced by means of the Koerting spray nozzle, is applied to the gas mixture. Fig. 10

shows an installation of this type for the absorption of hydrofluoric acid gas. A hood is placed over the pit and is connected to a wooden tower, to the top of which spray nozzles are attached. The vapors free of hydrofluoric acid gas pass through the outlet to a chimney or fan.

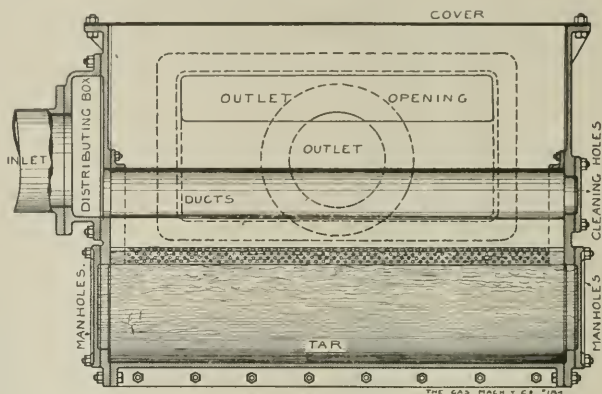


FIG. 7.—SECTION OF APPARATUS FOR ABSORBING AMMONIA FROM GASES.

On the Direct Reduction of Alumina by Carbon.¹

By R. S. HUTTON AND J. E. PETAVEL

The methods used in practice for obtaining aluminium from its ores are indirect and inefficient.

The purification involves a lengthy and complicated purification of the oxide, followed by its electrolysis in a bath of cryolite. Early work showed that where aluminium alloys are required they could be obtained by a simple method involving the reduction of alumina by carbon, but the process has never been successful for the production of the pure metal. Up to the present time opinion seems to be divided as to the

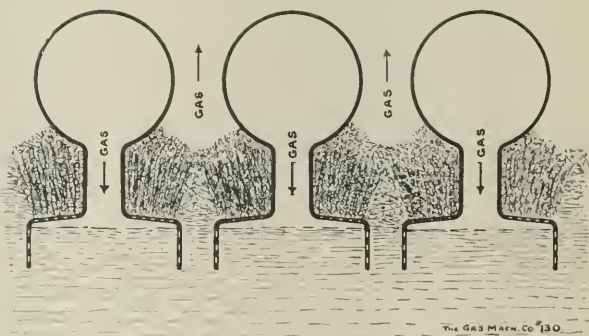


FIG. 8.—CROSS-SECTION OF DUCTS IN OPERATION.

effect of heating alumina and carbon together in the electric furnace.

Several authorities definitely state that alumina is irreducible by carbon,² whilst others affirm that it is quite easily reduced.³

¹ This is part of a paper read before the Royal Society of London, on electric furnace reactions under high gaseous pressure. While a brief summary of the chief results of this very extended investigation was already given on page 242 of our Vol. V., a fuller account will be found elsewhere in this issue.—Editor.

² W. Hampe, *Chemiker-Zeitung*, 1888, 12,391; S. A. Tucker and H. R. Moody, *Jour. Soc. Chem. Ind.*, 1901, 20,970.

³ Cowles, see W. P. Thompson, *Jour. Soc. Chem. Ind.*, 1886, Vol. V., p. 206; W. Borchers, *Elektro-Metallurgie*, third edition, 1903, p. 102.

Moissan,⁴ taking an intermediate position, asserts that the two materials only react when in the form of vapor.

The question, which for many reasons is of considerable importance, has never received the detailed investigation which it deserves.

Our experiments at atmospheric pressure, as we shall see, pointed to the fact that a well-marked thermal reaction does

which might be expected under the high gaseous pressures.

Some of the experiments tried under pressure to study this problem are given in Table I.

By a cursory inspection of Table I. the two following facts may be at once deduced:

(1) That in the resistance furnace neither aluminium nor its carbide is produced.

(2) That, on the other hand, all arc furnaces give a more or less marked reduction; although it will be noticed (in section B) that the product chiefly occurs as carbide of aluminium.

In several cases small malleable lumps of the metal were condensed in the powdered material surrounding the fused product.

From this it would appear that the required conditions for which we are searching had for some short period been accidentally fulfilled—these conditions being the rapid removal of the metal vapor from the reduction zone and its condensation under circumstances which preclude carburization.

The idea that, by reducing the partial pressure of the carbon monoxide by a circulation of hydrogen or coal gas, more favorable results would be attained led to the experiments quoted in Table I, C and D. From these we infer that the reaction is considerably favored by a dilution of the carbon monoxide. It is further noticeable that this precaution results in an increase in the relative quantity of aluminium metal, although it is still accompanied by a considerable amount of the carbide.

It therefore became evident that further work at high pressures must be preceded by a more detailed study of the conditions of reduction. The several problems which arise may briefly be stated as follows:

(1) At what temperature does alumina first show signs of reduction by carbon?

(2) In the production of aluminium alloys, what is the function of the auxiliary metal in facilitating the reduction of alumina?

(3) What precautions are necessary to limit the formation of carbide and increase the production of metal?

Since it is well known that alumina cannot be reduced under ordinary circumstances in the Moissan furnace, it was thought advisable to see whether, by carrying out the reaction in an atmosphere of hydrogen, a definite indication or reduction could be obtained. The Moissan furnace was, of course, modified to exclude the use of limestone and the accompanying production of carbon monoxide.

As will be seen from Table II. A, a negative result was obtained.

As a means of limiting the temperature of reaction, calcium fluoride was introduced, but no signs of reduction were apparent at the boiling point of the bath. From these and similar negative results at lower temperatures, which it is unnecessary to record, we assumed as a working hypothesis that the temperature of reduction of alumina is above the boiling point of aluminium metal under atmospheric pressure.

The hypothesis we confirmed by experiments (Table II. B), in which special precautions were taken to protect the material from access of air and to provide a condensing chamber in which the vapors were cooled down before their exit from the furnace. The deposit so obtained showed unmistakable evidence of the presence of finely divided aluminium.⁷

It therefore became necessary to devise some better means for indicating the production of any metal vapor.

A method which suggested itself to us, and one which has

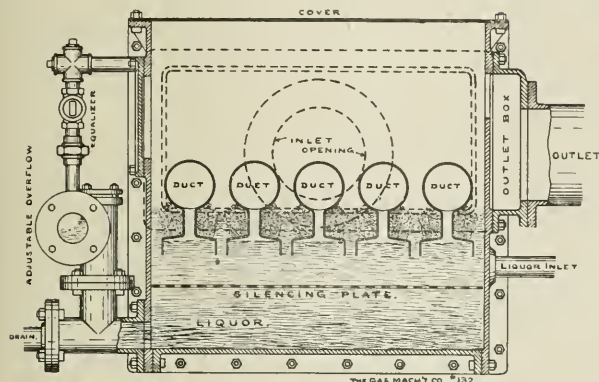


FIG. 9.—SECTION THROUGH WASHER ACROSS THE DUCTS.

take place, but not until the fusing point of alumina is reached.

Hérault,⁵ while admitting that reduction occurs, attributes it to electrolytic action. Having carried out some experiments in which the reacting substances were heated by radiation alone, and in which good yields of aluminium bronze were obtained, we contend that the assumption of electrolysis is by no means necessary.

No information was available as to the temperature of vaporization of metallic aluminium, but various observations led us to believe that a large proportion of the reduced metal

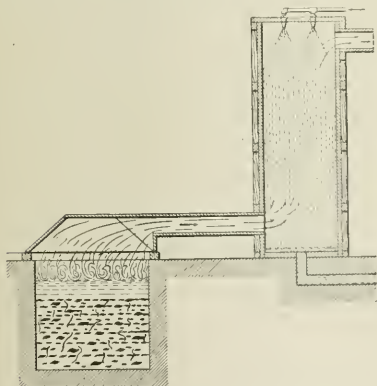


FIG. 10.—APPARATUS FOR ABSORBING HYDROFLUORIC ACID GAS.

was lost by volatilization and subsequent combustion where the furnace gases come in contact with the air.

The high-pressure furnace⁶ seemed to us, therefore, particularly suitable for studying this question, the advantages to be gained consisting in the complete protection of the products from oxidation, and secondly in the decreased volatilization

⁴ H. Moissan, *The Electric Furnace*, London Ed., Arnold, p. 184.

⁵ P. L. T. Hérault, Eng. Pat. 16,853. 1887; also Congress intern. des Mines et de la Metallurgie (Paris), 1900.

⁶ See the abstract of the complete paper of the author's in this issue.

⁷ See also C. F. Mabery, *Amer. Chem. Journ.*, 1887, Vol. IX., pp. 11-15.

proved of considerable usefulness, was the employment of a bath of molten copper, on the surface of which the reaction mixture was placed. The copper served as an absorbent for any aluminium vapor liberated.

To determine the lowest temperature at which reduction occurs, a series of experiments was carried out. Small carbon crucibles were used to contain the mixture. These were heated either in a carbon-tube furnace, or, for higher temperatures, more conveniently by embedding them in a granular carbon resistor. From the summary of these experiments in Table

aluminium can be so readily produced, no process exists by which the metal itself can be obtained from the oxide, except by indirect means. What is, then, the function of the auxiliary metal? It has been suggested that a marked chemical affinity exists between the aluminium and the metal with which it alloys, the evidence in support of this being the high heat evolution which is noticeable when aluminium is added to the metals in a molten state.

It must, however, be remembered that under ordinary conditions the fused metals contain dissolved oxide, and it there-

TABLE I.
A.—RESISTANCE FURNACE CO RETAINED.

Experiment No.	Total Energy, Kilowatt Hours.	Average Power, Kilowatts.	Initial Pressure, Atmospheres.	Maximum Pressure, Atmospheres.	Product, Grams Al Metal.	Product, Grams Al_2C_3 .	Observations.
G 19	16.0	9.6	63 air	157	Insignificant	Insignificant	Granular carbon core graphitized and containing much alumina fused around its particles.
G 41	2.5	9.0	6 nitrogen	25	Insignificant	Insignificant	Core of soot and alumina surrounded by pure alumina; to ascertain effect of fine division and intimate mixing. Tube of fused alumina around core, but no evidence of reduction.
G 44	3.2	6.5	Atmospheric	17	Insignificant	Insignificant	Experiment similar and confirmatory to G 41.
B.—ARC FURNACE, CO RETAINED.							
G 17	9.4	7.8	Atmospheric	44	5.0	47.7	Central cavity formed, having at bottom disc of fused reduction product resting on graphitized pillar of carbon.
G 32	4.6	8.2	Atmospheric	35	13.0	102	Similar to G 17.
C.—RESISTANCE FURNACE, CO DILUTED AND REMOVED.							
G 18	16.0	16.0	26 hydrogen	110	3.3	20.9	No diluting gas added during run. Resistant core granular carbon, after run no core remaining.
G 77	11.4	11.7	55 hydrogen	100	3.2	60.1	Current of hydrogen through hollow electrode during run, 900 litres; during cooling, 42 litres. Furnace with core of alumina and carbon between the two carbons.

D.—ARC FURNACE, CO DILUTED AND REMOVED.

G 20	7.2	17.2	39 coal gas	133	46	262	No diluting gas added during run. Some lime added to mixture. Fused product contained large amount of graphite flakes.
G 21	8.0	16.0	15 coal gas	25	49	106	The furnace was alternatively filled with coal gas to 25 atmospheres and gas blown down to 15 amperes; 600 litres coal gas during run; 1200 litres cooling period. Some lime added to mixture. Little graphite formation.
G 24	14.6	13.4	60 coal gas	90	31.8	198	Current of coal gas continuously passed through furnace at a rate of about 0.5 litre per second, pressure being maintained approximately constant at its maximum value.
G 33	9.1	9.8	15 coal gas	30	46	228	Regime of gas circulation similar to G 21. During run, 800 litres; during cooling about 800 litres also.
G 36	2.0	8.0	3 hydrogen	5	6.5	45	Reduction of alumina by calcium carbide. No diluting gas added during run.
G 75	15.3	9.8	50 hydrogen	70	17.7	130	Current of hydrogen through hollow carbon electrodes. During run, 900 litres; during cooling, 600 litres.
G 76	6.3	7.9	40 hydrogen	80	23.5	76.2	Regime of gas circulation similar to G 75. 510 litres during run; 450 litres during cooling.

N. B.—In all these experiments the mixture contained less than the theoretical amount of carbon.

In C, it will be seen that the minimum temperature of reduction coincides fairly sharply with the melting point of alumina, and is not appreciably lowered by the introduction of either fluorspar or lime as a flux.

By referring again to Table I. it will be found that this view is substantiated by a comparison between the arc and resistance experiments.

In the latter the yield is always extremely low. This may be explained by the fact that as the inner layer of mixture approaches its fusing point it flows away by gravity, and, ceasing to transmit the current, is not maintained at the requisite temperature for marked reduction to occur.

We now come to that curious apparent contradiction of facts which has for so long puzzled investigators in this field, namely, that though aluminium bronze and ferro-

fore seemed worth while to carry out a preliminary investigation of this question.

Upon adding aluminium to molten copper in a thoroughly reduced condition, there is no visible evidence of a reaction and such pyrometric measurements as were made sufficed to show that no considerable amount of heat could have been evolved.

Thus we feel justified in concluding that the copper or other metal serves chiefly to condense and dissolve the aluminium, and does not itself take part in the primary chemical reduction of the oxide.

A secondary function of the auxiliary metal is, however, possible. It occurred to us that the absence of aluminium carbide, when reduction is effected in the presence of other metals, might be explained by some chemical action of the

aluminium carbide upon the copper or iron or one of their oxides.

An investigation of this matter has been undertaken by J. N. Pring,* whose results clearly show that at the temperatures we are considering, namely, at or above the melting

the well-known affinity of aluminium for carbon monoxide,⁹ it is obviously important to remove this gas as completely and rapidly as possible.

A method of reducing the partial pressure of the carbon monoxide has been dealt with above, and we have found it im-

TABLE II.—EXPERIMENTS ON THE REDUCTION OF ALUMINA BY CARBON AT ATMOSPHERIC PRESSURE.

A.—RADIATION HEATING FROM ARC.					
Experiment Number.	E. M. F. on Furnace, Volts.	Current, Amperes.	Duration, Minutes.	Product.	Observations.
G 45	40	140	5	Fused Al_2O_3 . No Al metal or carbide.	Mixture corresponding to $\text{Al}_2\text{O}_3 + 2\text{C}$ placed under arc on alumina bed. Furnace enclosed. Hydrogen circulation.
G 46	25	240	14	Fused lump of Al_2O_3 . No Al metal or carbide.	Similar experiment to G 45.
G 47	40	300	10	No aluminium or carbide.	CaF_2 used as flux (28 per cent.) with same mixture as above. Heated until very rapid vaporization of fluorspar. Furnace ordinary Moissan type. Material in carbon crucible.
G 48	42	300	10	No aluminium or carbide.	Larger percentage of fluoride (61 per cent.), otherwise similar experiment to G 47.
B.—RESISTANCE CORE OF MIXTURE.					
Experiment Number.				Product.	Observations.
G 61	Total energy, about 1 kilowatt hour; power, 4 kilowatts.			Fused lump of alumina. No Al or carbide.	Cross-section of furnace hearth, 130 sq. centims.; length, 20 centims. Charge, consisting of central core of alumina and carbon surrounded by pure alumina. Thick iron plates served to cover furnace. No aluminium condensate obtained.
G 62	Total energy, 5.8 kilowatt hours; power, 7 kilowatts.			Condensate, but negligible Al in fused lump.	Similar construction to above, but cover fitting air-tight, and provided with long condensing chamber. Escaping gas deposited sublimate containing finely divided aluminium.
C.—APPROXIMATE ESTIMATION OF TEMPERATURE OF RÉDUCTION.					
Experiment No.	Mixture.	Temperature Estimated.	Result.	Observations.	
G 55	A.—10 grams ($\text{Al}_2\text{O}_3 + 2\text{C}$) + 40 grams Cu.	M. P. Ni.	No appreciable reduction.	Experiment in carbon tube furnace with careful adjustment of temperature.	
	B.—10 grams ($\text{Al}_2\text{O}_3 + 2\text{C}$) + 40 grams Cu.	M. P. Pt.	No appreciable reduction.	Experiment in carbon tube furnace with careful adjustment of temperature.	
	C.—10 grams ($\text{Al}_2\text{O}_3 + 2\text{C}$) + 40 grams Cu.	Above M. P. Pt, but below M.P. Al_2O_3 .	No appreciable reduction.	Experiment in carbon tube furnace with careful adjustment of temperature.	
G 57	A.—8 grams ($\text{Al}_2\text{O}_3 + 2\text{C}$) + 25 grams Cu + 10 grams CaF_2	Above M.P. Pt, but below M.P. Al_2O_3 .	No appreciable reduction.	Experiment in carbon tube furnace with careful adjustment of temperature (mixture well fused).	
	B.—72 grams ($\text{Al}_2\text{O}_3 + 2\text{C}$) + 25 grams Cu + 8.5 grams CaO	Above M.P. Pt, but below M.P. Al_2O_3 .	No appreciable reduction.	Experiment in carbon tube furnace with careful adjustment of temperature (mixture well fused).	
G 58	A.—10 grams ($\text{Al}_2\text{O}_3 + 2\text{C}$) + 50 grams Cu.	Just above M.P. of alumina.	46 grams aluminium-bronze (6.6 per cent. Al)	Crucible containing mixture embedded in granular carbon, covered with a second crucible containing alumina. Latter showed no sign of fusion.	
	B.—10 grams ($\text{Al}_2\text{O}_3 + 2\text{C}$) + 50 grams Cu.	Considerably higher temperature.	40 grams aluminium-bronze (7.8 per cent. Al).	Similar construction alumina in upper crucible also fused. All the mixture either combined or volatilized.	

point of alumina, aluminium carbide reacts with either the oxide or the metal, forming an alloy.

The third problem, viz., the limitation of the formation of carbide, seems to be the most difficult to solve.

As we have seen, the metal may be considered to exist in the form of vapor at the moment of its reduction. Owing to

important to lead the gas used for dilution directly to the seat of reaction by means of a hollow electrode, the stream of gas thus not only effectively diluting the carbon monoxide, but serving to carry forward the metallic vapor into a zone more favorable for its condensation.

Even in the absence of carbon monoxide, carburization can

* J. N. Pring, Trans. Chem. Soc., 1905, Vol. LXXXVII., p. 1530.

⁹ Guntz and Masson, Comptes Rendus, 1897, Vol. CXXIV., p. 187.

occur by direct union of the metal with solid carbon.

Some unpublished work of W. H. Patterson carried out in this laboratory has, however, shown that in the absence of carbon monoxide this reaction only occurs above a bright red heat, thus explaining the results already quoted in which the metal was obtained, although doubtless it had not altogether escaped contact with carbon.

We are, therefore, in the following position: we have proved the facility with which the direct reduction of alumina by carbon can be effected, and have shown the minimum temperature at which it can occur is already sufficiently high for the metal to be produced in the form of vapor.

Future work must be directed towards the application of high pressure for reducing the vaporization of the metal at the temperature of reaction, the rapid removal or dilution of the carbon monoxide by a steam of inert or reducing gas, and a modification of the *régime* to facilitate the condensation and prevent the collected metal from flowing into a bed of highly heated carbon.

Thus the necessary conditions for the successful direct reduction of alumina by carbon seems to be fairly well defined, the outstanding problem being chiefly a matter of the arrangement and construction of the furnace.

The Von Bauer Coke-Oven System.

The by-product coke-oven system described in this article has been devised by Dr. Theodor von Bauer, who is one of the most experienced coke-oven engineers in Germany. In its present state his system is the outcome of changes and improvements which have been made gradually in the course of years. The von Bauer coke-oven patents are controlled in Europe by the Berlin-Anhaltische Maschinenbau Aktien Gesellschaft (commonly known in Germany by the abbreviation "Bamag"). This company is noted as very large builders of gas works and manufacturers of apparatus for all kinds of gas plants; they have also shipped much of their machinery to this country. To take care of the construction of the von Bauer coke-ovens, the Gesellschaft für Erbauung von Hüttenwerksanlagen, Düsseldorf, Germany, a subsidiary company of the Bamag, has been founded. Its chief engineer is Mr. O. Simmersbach, well known as a high authority on this subject and as the author of a book on the chemistry of coke.

This coke-oven system is now being introduced into this country by Mr. David B. Carse, formerly of the United States Steel Corporation, and by Mr. Frederick J. Mayer, a distinguished gas engineer. As this system is radically different from others now in use, a detailed description should be interesting at this moment. The following description is based in its first part on an article by Mr. O. Simmersbach in *Stahl und Eisen* (No. 24, 1906). Some recent improvements effected by Dr. von Bauer since the publication of that article will then also be noted.

In the latest design of the von Bauer coke ovens longitudinal flues are provided on top of the combustion chambers between the coking chambers. These two flues are arranged immediately above each other. All the upper flues communicate with the lower flues of the same set by means of a series of openings, and in a similar manner, also, with the upper flues of the adjoining sets across the tops of the intervening coking chambers. The lateral flue connections also pass over the charging openings on top of the coking chambers.

This flue arrangement assures not only a uniform distribution of the fuel gases into the vertical combustion chambers, but also in the case of "direct" operation a uniform composition of the same by mixing the crude gases from the coking chambers, which, naturally, vary in their composition, according to the more or less advanced state of the coking process in the various chambers of the battery, in the upper

flues before entering the lower distributing flues and from there the combustion and heating chambers.

In the case of "indirect" operation, the auxiliary fuel gas supply enters the upper and lower flues from the outside, and is distributed in the upper and lower flues from the outside and is distributed in the lower flues into the combustion or heating chambers. The change from the "direct" operation of the coke to the "indirect" is accomplished by disconnecting the upper flue system from the charging openings on top of the coking chambers and using the upper and lower flues for the reception, mixing and distribution of the fuel gases coming from the condenser or of auxiliary fuel gases from other sources into the combustion chambers.

The design of the latest improved coke oven, as it was at the writing of Mr. Simmersbach's article in 1906, is shown in the accompanying illustrations, Figs. 1 to 5.

Fig. 1 represents a vertical section through the upper part of a number of coking chambers, showing the method of operating a "direct-fire" coke oven for "hand" charging (A), a "direct-fire" coke oven for "machine" charging (B), as well as the method of operating a "by-product" coke oven for hand charging (C) and for machine charging (D).

Fig. 2 represents a vertical section through the combustion chambers; Fig. 3 a similar section through a coking chamber of a coke oven.

Fig. 4 represents a horizontal section, showing at a reduced scale the arrangement of the upper and lower flue systems.

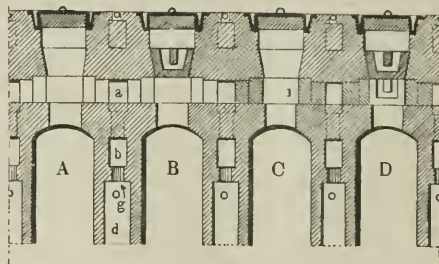


FIG. 1.—THE DIFFERENT METHODS OF OPERATING THE VON BAUER COKE OVEN.

- A = "Direct Fire" with hand charging.
- B = The same with machine charging.
- C = "Indirect Fire" or By-Product oven with hand charging.
- D = The same with machine charging.

Fig. 5 represents a vertical cross-section, showing the end of a battery of coke ovens with flue for the removal of the surplus gases.

Above the walls between the coking chambers are located the mixing flues *a*, which are in connection with the charging chutes, or shafts of the coking chambers, and also with the adjoining mixing flues. Below the mixing flues *a* and in the walls between the coking chambers are located the distributing flues *b*, which communicate with the mixing flue above and with the combustion chambers or heating flues below; the latter being also arranged in the walls between the coking chambers.

By the "direct" operation of the coke oven and "hand" charging, it is only necessary to insert the covers for the charging openings in top of oven (Fig. 1 A), while for "machine" charging the additional lower removal covers are inserted and made gas tight with a filling (Fig. 1 B). In both cases, however, the mixing flue system *a* remains in connection with the charging openings in the top of the coking chambers as well as with the distributing flue systems *b*.

The crude gases generated in the coking chambers, and which vary as to their composition, enter the mixing flue system *a*, where they are mixed so as to attain a more uni-

form composition. From this mixing flue system *a* the gases pass into the distributing flue system *b*, and from there finally through the openings *g* into the combustion chambers or

Hanover, between Jan. 1, 1903, and June 1, 1904, an increase of more than 5 per cent in the yield of coke over that obtained by the crucible test was regularly observed. This is mainly

due to the uniform maintenance of the conditions of temperature, which favor a partial decomposition of the heavy hydrocarbons and a subsequent deposition of part of the carbon therefrom upon the coke, and to the arrangement and location of the flues for the preheating of the air supply for the combustion chamber, which precludes any possibility of air entering the coke chambers.

In "by-product" coke ovens these conditions differ in so far as after the charging of a coking chamber (Fig. 3 A), the generated gases rise through the standpipe B into the gas main M leading to the by-product plant for the extraction of tar, ammonia and benzol. The purified gases are returned through the mains R, and by means of special individual connections introduced as fuel gas into the mixing and distributing flue systems *a* and *b*.

The provision of a regulating

device on these individual connections affords a much closer adjustment of the gas supply than it would be possible with a number of single tuyeres. The reason for this is that a possible more or less of the gas supply at any point will be automatically adjusted by distribution in the mixing and dis-

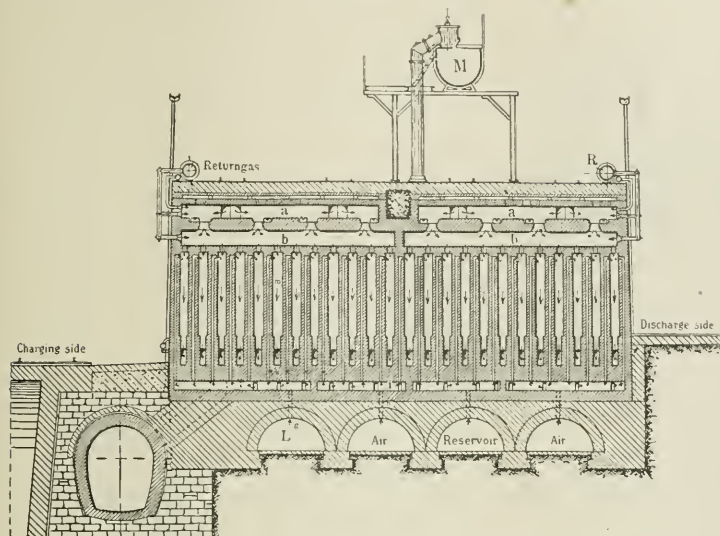


FIG. 2.—SECTION THROUGH THE COMBUSTION CHAMBERS.

heating flues *d* in the walls between the coking chambers. In order to operate the coke ovens on the "indirect" system it is only necessary to close the connections between the mixing flue system *a* and the charging chutes, or shafts, by means of firebricks *i*. By "hand" charging (Fig. 1 C) only one cover is used for the closing of the shaft, but by machine charging (Fig. 1 D) an additional cover with sand filling is used.

In the coke ovens thus arranged for "indirect-fire" operation, the flue systems *a* and *b* receive the purified gases from the oven, or an auxiliary fuel gas supply, from another source for distribution into the combustion chambers in the same manner as the crude gases when operating the ovens "direct." The auxiliary gas supply may be used exclusively or for mixing with the purified gases from the coke ovens.

A small steam pipe discharging into the mixing flue *a* is used for blowing out from time to time any soot that may accumulate when operating the coke ovens "direct." This avoids the necessity of cleaning these flues by hand, which otherwise would result in loss of time, cooling of the flues, etc., if the cleaning were to be effected by hand.

One point of superiority of this coke-oven construction is an increased yield of coke. The yield is even greater than that obtained by the crucible test. Thus, on the Krupp colliery,

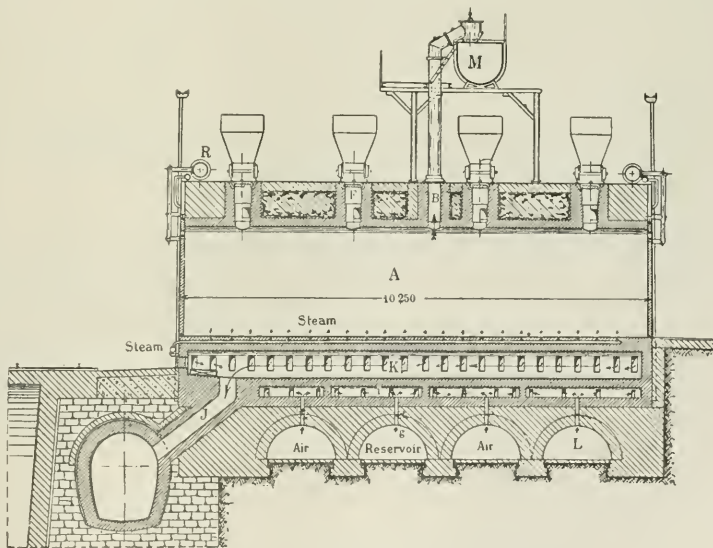


FIG. 3.—SECTION THROUGH THE COKING CHAMBERS.

tributing flue system before the fuel gas enters the combustion chambers.

A uniform gas supply will naturally result in a correspond-

ingly uniform supply of air for the combustion. From the flue systems *a* and *b* the gases enter the combustion chambers (Fig. 2 *m*), where they meet the highly preheated air. The gases of combustion are then drawn down and collected in the collecting flues *K*, located under the coking chambers (Figs. 3

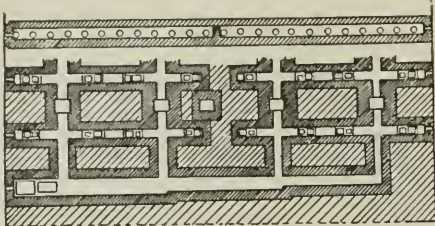


FIG. 4.—HORIZONTAL SECTIONS THROUGH THE UPPER AND LOWER DISCHARGING FLUE SYSTEM.

and 5), and discharged through the connecting flue *J* into the main flue, to be either further used in boiler furnaces or finally discharged through a chimney.

The air for combustion is taken from the spaces under the ovens formed by the large foundation arches. These arches serve for the preliminary heating of the air supply as well as for the cooling of the oven foundations. This arrangement restricts the required openings in the sides of a battery of ovens to those required for the charging and discharging of the coking chamber of machinery and in the top to those required for admission of coal in the case of hand charging and for the necessary gas take-offs.

In case the ovens are charged with machinery, the charging openings *A* top are then closed with suitable form blocks, so as to avoid any admission of air into the ovens by that source.

The air for the combustion is supplied in four separate sections, one for each of the four large foundation arches under the battery of coke ovens, the air in-lets to which are provided with adjusting dampers. From these large air reservoirs the air enters through the openings *g* and *h* into the distributing ducts *i*, in which the air, being exposed to the heat from the gas flue *K*, is heated to about 1,100° F. From the distributing ducts *i* the air rises through special up-takes,

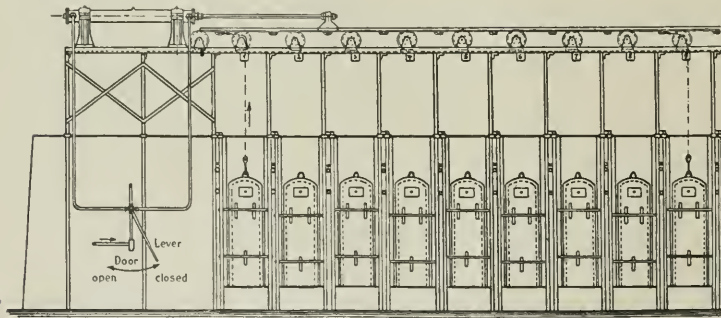


FIG. 6.—ELEVATION OF A BATTERY OF OVENS WITH AUTOMATIC DEVICE FOR OPENING AND CLOSING THE DOORS.

molded in the material forming the walls of the coking and combustion chambers, thereby extracting more and more heat from these walls and increasing its own temperature to about 1,020° F., as has been proven by measurements with electric and optic pyrometers on various coke ovens of this system.

Because of the highly preheated air the combustion is naturally complete, and the resulting high temperature is produced in the combustion chamber at and below the surface line of the coal charge in the coking chamber. Furthermore, as the gases

of combustion have a downward course, high temperatures and the resulting superheating of the upper parts of the coking chambers are prevented, and thus also any decomposition of the valuable gases in the coking chamber before their removal through the stand-pipe *B* into the collecting main *M*.

The average coking period in the new coke ovens is 24 hours, which corresponds to a yearly capacity of 180,000 to 190,000 tons of blast-furnace coke for a battery of 100 ovens. The ovens yield from 45 to 50 per cent surplus gas, according to the kind of coal used, while the flue gases, because of their short travel, have a higher temperature than those from such other coke-oven systems, where the flue gases have to pass extensive generators and checkwork, which necessarily reduce their heating value. Furthermore, the omission of complicated and costly devices for the preheating of the air for combustion reduces the cost of construction of the new ovens considerably and at the same time simplifies their installation and operation.

Numerous tests have demonstrated that in the regular operation of the new von Bauer coke ovens the transmission

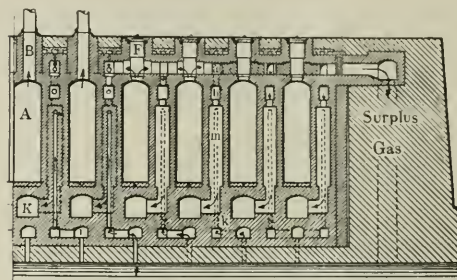


FIG. 5.—CROSS-SECTIONS; END OF BATTERY WITH WASTE HEAT FLUE.

of heat from the walls of the coking chambers to the coal in the coking chamber is gradually reduced towards the end of the coking period, and that the layer of coke nearest the heated wall and the gases generated in the chamber become hotter in the ratio as the coking process advances towards the

center of the charge of coal; in fact, so much that during the last third of the coking period the heating of the coking chambers can be dispensed with entirely.

In order to facilitate the completion of the coking process during this period, especially of the inner core of the coal charge, steam is admitted into the coking chamber through a special and patented device, for the purpose of more uniformly transmitting the heat from the walls of the coking chamber through the cracks and pores of the finished outer coke layer to the coking core

of the coal charge. Actual experience has proven that with this arrangement the coking period of the new ovens is shorter and the coking process more uniform than without the same. Another advantage of this arrangement is that it increases the yield of the surplus gas considerably, and that, because of the lower temperature of the gases generated during that period, less washing and condensation surfaces are required.

According to Prof. Kassner, of Muenster, the above-described

device applied to by-product coke ovens increases the yield of gas by 30 per cent, and that of tar and ammonia by 50 per cent over the previously possible yields.

The lifting and lowering of the doors of the von Bauer coke ovens are accomplished through a special automatic hoisting apparatus. With this apparatus all doors of one battery can be operated from one place, as it is only necessary to attach a chain to any door and operate the steering valve of the hoisting apparatus, and as this is very light work it can be done

movable rod. Upon opening the supply for the source of power to the front of the cylinder, the piston is moved back, and as the piston rod is coupled to the lifting rod for the doors, the rod is moved to the side and the doors lifted. In order to close the doors, the steering valve of the hoisting apparatus is set so as to release the source of power from the front part of the cylinder, either by letting the same escape or by transferring the same to the other side of the piston.

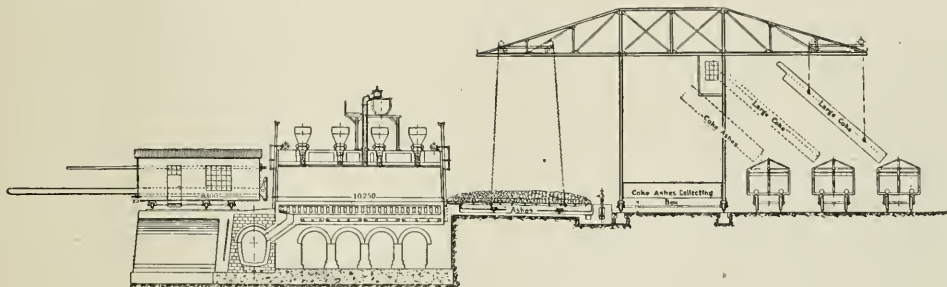


FIG. 7.—TRAVELING COKE-HANDLING DEVICE.

by boys. The hoisting or the lowering of a coke-oven door requires not more than from 3 to 5 seconds.

Fig. 6 shows the general arrangement of the apparatus for the hoisting and lowering of the coke oven doors. As a rule, the buckstays of the oven settings are extended a certain distance above the top of the setting, and there connected to each other by a continuous member of shape iron. Upon the latter and over each oven door is placed a small idler for the lifting chain or cable on the same shaft with a larger roller. The latter rollers support a rod, which is provided with suitable eyes or hooks to receive the corresponding hook or eye

For larger installations of these coke ovens the following electrically-operated device for loading coke direct from the coke ovens into railroad cars has proven to be of great advantage. The device consists of a traveling crane about 33 feet high, with cantilevers 30 feet long and a hoisting trolley with four hoisting cables or chains. Near the base of the four columns of the crane frame is arranged a reservoir for the coke ashes. The coke from the coke ovens is taken up in coke pans, constructed of sheet and shape iron, and arranged on wheels so that they can be placed in front of any of the ovens in the battery. The upper half of these coke pans is arranged

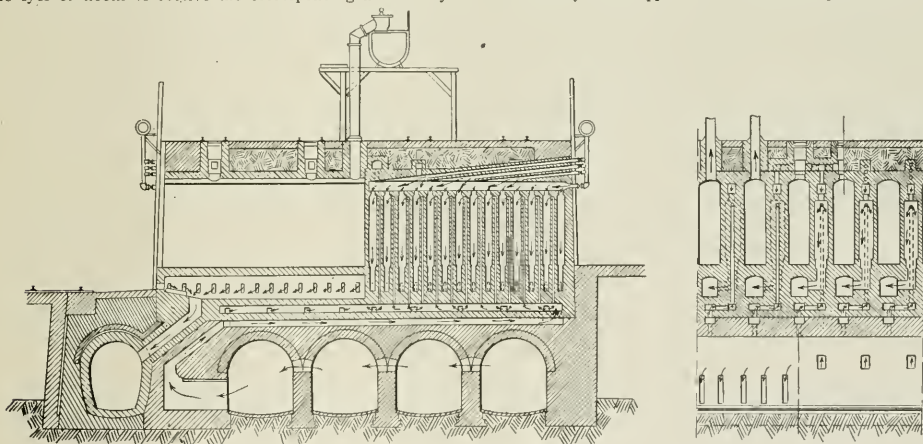


FIG. 8.—LATEST CONSTRUCTION OF VON BAUER COKE OVEN.

on the end of the hoisting chain for each door. At one end the rod is coupled in a suitable manner to the piston rod of a working cylinder, which may be operated either by steam, water or compressed air.

The method of operating the device is the following:

As soon as one or more doors are to be opened, the lower hooks on the hoisting chains or cables are attached to the corresponding eyes on the doors, the chains or cables laid over the small idlers above the doors, and the free ends of the chains attached to the corresponding hooks or eyes on the

as a grate of sufficient length and width to allow for the charge of one coke oven to be conveniently spread out and quenched. The grate is constructed of flat iron on edge, with spaces $\frac{3}{8}$ inch to $\frac{5}{8}$ inch in the clear. Usually a coke pan of this character is about 30 feet long by 8 feet wide in the clear.

The method of operating this device is the following:

As soon as one coking chamber is to be discharged the coke pan is placed in front of the oven, and the discharging machine pushes the finished coke upon the coke pan, and two men immediately spread and quench the coke. In order to allow

the coke to cool, the finished coke from another oven is pushed upon a second coke pan. In case the coke upon the first coke pan is sufficiently cool for loading, the eyes at the ends of the four hoisting cables of the hoisting trolley are attached to the corresponding hooks on the coke pan and hoisted to a height of about 15 feet and run over an empty railroad car. In this position the hoisting mechanism of the hoisting trolley is disconnected from the two front cables, while the two rear cables are further wound up so as to slowly bring the coke pan in an inclined position, which causes the coke to slide off and the the coke ashes to fall through the grating in the bottom of the coke pan, after which the hoisting trolley with the coke pan in the inclined position is run over the ash reservoir, and the accumulated ashes, by opening a damper at the head of the ash box under the grating, deposited in the ash reservoir.

The empty coke pan is then lowered and placed upon the track in front of the ovens ready for the next filling. In the meantime the coke in the second coke pan is sufficiently cooled for loading.

The entire process of loading the charge of a coke oven—that is, attaching the hoisting cables of the hoisting trolley to the coke pan, lifting, running the hoisting trolley to the position for loading the railroad car, unloading the coke and ashes from the coke pan, returning and lowering of the coke pan upon the tracks in front of the coke ovens—requires 10 minutes.

The required labor in connection with the quenching and loading of the coke from forty to fifty coking chambers can be conveniently accomplished by three men in 10 hours, which would correspond to a capacity of the traveling crane of eighty to 100 coking chambers in 24 hours.

Since the publication of Mr. Simmersbach's article, from which the above description is taken, Dr. Th. von Bauer has arranged for other important improvements in connection with the regulation of the fuel gas supply to the distributing flues in the upper part of the oven, by omitting the internal adjusting tiles and substituting the same by independent direct gas supply to different parts of the flue, controlled by valves, all located immediately opposite the upper parts of the partition walls and easily accessible on both sides of the ovens. The matter of preheating the air for combustion has also been improved in this last construction, by lengthening the ducts under the main combustion flue of the ovens. While an installation of the older von Bauer system is at Sydney, Nova Scotia, the new system is to be used in a plant soon to be built in this country.

Metallurgical Calculations.

By J. W. RICHARDS,
Professor of Metallurgy in Lehigh University.

The Metallurgy of Silver and Gold.

The processes most used for the extraction of silver and gold from their ores are the smelting of the ores with copper ores to matte and eventually blister copper, followed by electrolytic refining of the latter, or smelting with lead ores, followed by desilverization of the resulting lead bullion, cupellation of the rich lead, or electrolytic refining of the same. In all of these cases the silver or gold is a comparatively minute constituent of the ore, intermediate products and final metal, so that the metallurgy of silver or gold, after these methods, up to the production of impure silver or gold, or silver or gold bullion, is practically the metallurgy of copper or lead—both of which subjects we have considered at length.

When we obtain products in which the silver or gold is the chief constituent, we approach a condition in which calculations upon the precious metal contained may be based, but here again there are not the same conditions of economy so prominent in the metallurgy of lead or copper. It does not

matter greatly, for instance, whether we use 50 cents' worth of one fuel or a dollar's worth of another in melting 1,000 ounces of silver worth over \$500; the question of which fuel is the cleanest or most convenient is of greater importance than the costs of the fuels.

The object of this introduction is to show that, until it comes to handling nearly pure silver or gold, close calculations as to amounts of reagents, running of furnaces, etc., are not practicable for silver or gold *per se*.

ELECTROLYTIC REFINING OF SILVER BULLION.

The parting of gold and silver by acids is rapidly giving place to the cleaner and less expensive electrolytic separation. The bullion may be of very variable composition. The following analyses of two samples give an idea of this variation:

	<i>Cupelled Silver.</i>	<i>Impure Silver.</i>
Ag	98.69	74.08
Pb	1.09	3.71
Cu	0.12	20.23
Fe	0.09	1.01
Au	0.0023	0.05

The electrolytic refining proceeds easiest with the nearly pure silver, because the impurities going into solution accumulate much more slowly, and the solution therefore requires purifying less frequently. On the other hand, the solution of a large amount of copper, iron or lead adds electromotive force to the circuit, since silver only is deposited, and thus decreases the electrical work to be done.

Problem 126.

Two varieties of silver bullion are refined electrolytically, carrying

	<i>No. 1.</i>	<i>No. 2.</i>
Ag	98.69	74.08
Pb	1.09	3.71
Cu	0.12	20.23
Fe	0.09	1.01
Au	0.01	0.05

The slimes from each carry in percentages:

	<i>No. 1.</i>	<i>No. 2.</i>
Ag	60	55
Pb	10	5
Cu	5	15
Fe	3	5
Au	22	20

In each case all the gold goes into the slimes. A current density of 200 amperes per square meter of electrode surface is used, and the plates are 2 centimeters thick. Specific gravity of No. 1, 10.15; of No. 2, 9.79. There is anode scrap equal to 12 per cent of the weight of the plates. The working space between the electrodes is 4 c.m., total current 220 amperes per tank, specific resistance of electrolyte 20 ohms. Deposited silver, 19.85 kg. per tank per day.

Required:

- (1) The ampere efficiency of the deposition of silver.
- (2) The weight of anode corroded in a tank per day.
- (3) The deficit in weight of silver in the electrolyte in each tank per day.
- (4) The electromotive force contributed to the circuit by the solution of impurities in the case of each bullion.
- (5) The total drop of potential across each tank, adding 10 per cent for loss in contacts.
- (6) The horsepower-hours required per kilogram of silver deposited in each case.

Solution:

- (1) Silver deposited theoretically by one ampere
per day, $0.00001035 \times 108 \times 60 \times 60 \times 24 = 96.58$ grms.
220 amperes deposits $96.58 \times 220 = 21.248$ "
= 21.248 kg.

$$\text{Ampere efficiency} = \frac{19.85}{21.248} = 0.934 = 93.4 \text{ per cent. (1)}$$

This means that 0.6 per cent of all the silver which the current is capable of depositing is prevented from depositing by the nitric acid present, forming AgNO_3 . The electrolyte is silver nitrate with copper nitrate, and contains always about 1 per cent of free nitric acid, which thus acts chemically upon the deposited silver (or acts to prevent its deposition to this extent, whichever way we wish to look at it).

(2) The weight dissolved, per 100 grams of anode corroded, is, assuming all the gold to appear in the slimes:

	No. 1.		
	Anode.	Slimes.	Dissolved.
Ag	98.69	0.03	98.66
Pb	1.09	....	1.09
Cu	0.12	....	0.12
Fe	0.09	....	0.09
Au	0.01	0.01	....

	No. 2.		
	Anode.	Slimes.	Dissolved.
Ag	74.08	0.14	77.94
Pb	3.71	0.01	3.70
Cu	20.23	0.04	20.19
Fe	1.01	0.01	1.00
Au	0.05	0.05	....

The amount of current necessary to dissolve these weights will be the sum of the current which would be necessary to dissolve each constituent separately. These will be found in ampere-hours by dividing each by its electrochemical chemical equivalent $\times 3,600$.

	No. 1.		Ampere-Hours.
Ag	98.66	$\div 0.001118$	$\times 60 \times 60 = 24.51$
Pb	1.09	$\div 0.00107$	$\times 60 \times 60 = 0.28$
Cu	0.12	$\div 0.00033$	$\times 60 \times 60 = 0.12$
Fe	0.09	$\div 0.00029$	$\times 60 \times 60 = 0.09$
			25.00

	No. 2.		
Ag	77.94	$\div 4.025$	$= 19.36$
Pb	3.70	$\div 3.856$	$= 0.96$
Cu	20.19	$\div 1.185$	$= 0.96$
Fe	1.00	$\div 1.044$	$= 0.96$
			38.32

Since there is disposable $220 \times 24 = 5,280$ ampere-hours in a tank per day, there will be corroded the following weights of anodes per day in tanks containing Nos. 1 and 2, respectively:

No. 1.....	$100 \times \frac{5,280}{25}$	$= 21,120$ Grams.
No. 2.....	$100 \times \frac{5,280}{38.32}$	$= 13,779$ "

(3) There is dissolved in a tank, per day, the following weights of silver:

No. 1 anodes:	$21,120 \times 0.9866$	$= 20,837$ Grams.
No. 2 anodes:	$13,779 \times 0.7794$	$= 10,739$ "
Deposit in each tank		$= 19,850$ "
Surplus in No. 1 tank		$= 987$ "
Deficit in No. 2 tank		$= 9,111$ " (3)

(4) The heats of formation of the acid and salts concerned are:

(Ag, N, O ¹ , Ag)	$= 23,000$ cal.	$= 213$ cal. per gram Ag.
(Pb, N ³ , O ⁶ , Ag)	$= 98,200$ "	$= 474$ " " Pb.
(Cu, N ³ , O ⁶ , Ag)	$= 81,300$ "	$= 1,278$ " " Cu.
(Fe, N ³ , O ⁶ , Ag)	$= 43,900$ "	$= 784$ " " Fe.
(H, N, O ¹ , Ag)	$= 48,800$ "	$= 48,800$ " " H

The heat balance per 100 grams of anodes No. 1 is:

Solution of Ag,	98.66×213	$= 21,015$ cal.
" Pb,	1.09×474	$= 517$ "
" Cu,	$0.12 \times 1,278$	$= 153$ "
" Fe,	0.09×784	$= 71$ "
Heat evolved		$= 21,756$ cal.
Deposit'n of Ag,	93.99×213	$= 20,020$ "
Liberat'n of H ²	$0.06 \times 48,800$	$= 2,928$ "
Heat absorbed		$= 22,948$ "
Heat deficit		$= 1,192$ "

Since this is per 25 ampere-hours [see (2)] and 1 ampere-hour at 1 volt = 860 calories, the voltage which this deficit of energy will absorb in the case of anodes No. 1 is:

$$1,192 \div 25 \div 860 = 0.06 \text{ volt. (4)}$$

The similar calculation for anodes No. 2 gives per 100 grams corroded:

Solution of Ag,	77.94×213	$= 16,601$ cal.
" Pb,	3.70×474	$= 1,745$ "
" Cu,	$20.19 \times 1,278$	$= 25,803$ "
" Fe,	1.00×784	$= 784$ "
Heat evolved		$= 44,942$ cal.
Deposit'n of Ag,	98.11×213	$= 20,897$ "
Liberat'n of H ²	$0.06 \times 48,800$	$= 2,928$ "
Heat absorbed		$= 23,825$ "
Surplus heat		$= 21,117$ "
Voltage generated		$= 0.98$ volt. (4)

(5) Resistance of each element of electrolyte of 1 square c.m. area is $20 \times 4 = 80$ ohms. The current passing through this is $220 \div 10,000 = 0.022$ amperes. The drop of voltage, due to the resistance of the electrolyte, is, therefore,

$$0.022 \times 80 = 1.76 \text{ volts.}$$

Adding decomposition voltage we have

In case of No. 1 anodes,	$1.76 + 0.06 = 1.82$ volts.
Add for resistance of contacts	0.18 "
Working voltage	2.00 " (5)
In case of No. 2 anodes,	$1.76 - 0.98 = 0.78$ "
Add for resistance of contacts	0.18 "
Working voltage	0.96 " (5)

(6) Horsepower required per tank:

Anodes No. 1	$\frac{220 \times 2.00}{750}$	$= 0.59$ hp.
Anodes No. 2	$\frac{220 \times 0.96}{750}$	$= 0.28$ "

Power per kilogram of silver deposited:

Anodes No. 1,	$0.59 \div 19.85$	$= 0.020$ hp.-days.
		$= 0.48$ hp.-days. (6)
Anodes No. 2,	$0.28 \div 19.85$	$= 0.014$ hp.-days.
		$= 0.34$ hp.-days. (6)

Problem 127.

The Wohlwill process for refining gold bullion operates with AuCl³ solution, strongly acid with HCl. Design a plant for refining bullion having the analysis:

Au	60.3	Fe	2.2
Ag	7.0	Ni	2.0
Cu	6.5	Pb	7.0
Zn	15.0		

Assume the following data to start with:

Current density, 1,000 amperes per square meter.

Use ten tanks in series.

Tanks available, 500 m.m. × 500 m.m. × 300 m.m. deep, inside.

Electrodes about 4 c.m. apart.

Starting sheets 1 m.m. thick.

Anodes 20 m.m. thick.

Specific gravity of anodes 17.5.

Gold present in solution 50 grams per liter.

Specific resistance of electrolyte 5 ohms.

Specific gravity of the electrolyte 1.15.

Loss of electromotive force at contacts one-half the loss due to the resistance of the solution.

Anode products, AuCl³, AgCl, CuCl, ZnCl², FeCl², NiCl², PbCl².

Required:

(1) The size and dimensions of electrodes and number in a tank.

(2) Current used and total voltage of the system.

(3) Gold deposited per day.

(4) Anodes corroded per day, assuming corrosion uniform.

(5) Deficit of gold in the tanks per day.

(6) If anodes are left in until 9/10 dissolved, how long will they last?

(7) If cathodes are removed every 24 hours, what is the average time of treatment?

(8) At 6 per cent per annum, what is the interest charge per kilogram of gold under treatment in the plant, gold being worth 72.9 cents per gram?

Solution:

(1) Allowing 1 c.m. clearance at the sides, the plates must not be over 48 c.m. in width across the tank. The electrolyte must not be nearer than 2 c.m. to the top of the tank, and the plates ought to be 8 centimeters above the bottom, to allow space for slimes to accumulate. The immersed depth of plates is, therefore, 40 c.m., and the superficial area 960 sq. c.m. on a side.

With spaces 4 c.m., anodes 2 c.m. thick and cathodes 0.1 c.m., using one more cathode than anode, we have the spaces equal in number to twice the anodes, and, therefore,

(2 × anodes) + (anodes + 1) 0.1 + (2 anodes + 4) = 50, whence the number of anodes figures out 4.9. (1)

Choosing the nearest whole number, 5, there will be 6 cathodes, and the working spaces will be 10, and their width

$$\frac{50 - 5(2) - 6(0.1)}{10} = 3.94 \text{ c.m.} \quad (1)$$

(2) Ignoring the edges of the plates, the working surface per tank is 960 × 2 × 5 = 9,600 sq. c.m., and the current 9,600 ÷ 10,000 × 1,000 = 960 amperes. (2)

The voltage to overcome ohmic resistance is

$$5 \times 3.94 \times \frac{1,000}{10,000} = 1.97 \text{ volts.}$$

$$\text{Add 50 per cent loss at contacts} = 0.98 \text{ "}$$

$$\text{Sum} = 2.95 \text{ "}$$

The voltage corresponding to the chemical action occurring can be calculated from the energy of formation of the AuCl³ decomposed minus the energy of formation of the salts formed. More simply, although not so logically, it may be derived from the voltages of decomposition of these compounds, allowing for the proportions of each formed and decomposed. These are:

$$\begin{aligned} (\text{Au, Cl}^3) &= 27,200 \div 3 \div 23,040 = 0.393 \text{ volt.} \\ (\text{Ag, Cl}) &= 29,000 \div 1 \div 23,040 = 1.257 \text{ "} \\ (\text{Cu, Cl}) &= 35,400 \div 1 \div 23,040 = 1.536 \text{ "} \\ (\text{Zn, Cl}^2) &= 113,000 \div 2 \div 23,040 = 2.448 \text{ "} \\ (\text{Fe, Cl}^2) &= 100,100 \div 2 \div 23,040 = 2.170 \text{ "} \\ (\text{Ni, Cl}^2) &= 93,900 \div 2 \div 23,040 = 2.037 \text{ "} \\ (\text{Pb, Cl}^2) &= 77,900 \div 2 \div 23,040 = 1.690 \text{ "} \end{aligned}$$

These are the voltages which would be generated at the anode in case each one of these salts was the only salt being formed. But, since we know the exact composition of our anode dissolved, we can calculate the corresponding voltage generated at the anode:

$$\begin{aligned} \text{Au, } 0.603 \times 0.393 &= 0.237 \text{ volt.} \\ \text{Ag, } 0.070 \times 1.257 &= 0.088 \text{ "} \\ \text{Cu, } 0.065 \times 1.536 &= 0.101 \text{ "} \\ \text{Zn, } 0.150 \times 2.448 &= 0.367 \text{ "} \\ \text{Fe, } 0.022 \times 2.170 &= 0.048 \text{ "} \\ \text{Ni, } 0.020 \times 2.037 &= 0.041 \text{ "} \\ \text{Pb, } 0.070 \times 1.690 &= 0.118 \text{ "} \end{aligned}$$

	Sum	1.000	"
Absorbed at the cathode		0.393	"
Total voltage generated		0.607	"
Absorbed in electrolyte and connections		2.95	"
Working voltage per tank		2.34	"
Total for the system		23.4	" (2)

(3) Au deposited by 960 amperes in ten tanks per day:

$$\frac{0.00001035 \times 197}{3} \times 60 \times 60 \times 24 \times 960 \times 10 = 563,729 \text{ gr.} = 563.729 \text{ kg.}$$

(4) One gram of anode requires for its corrosion:

$$\begin{aligned} \text{Au, } 0.603 \div 197 &\div 3 \div 0.00001035 \\ \text{Ag, } 0.603 \div 108 &\div 0.00001035 \\ \text{Cu, } 0.065 \div 63.6 &\div 0.00001035 \\ \text{Zn, } 0.150 \div 65 &\div 2 \div 0.00001035 \\ \text{Fe, } 0.022 \div 56 &\div 2 \div 0.00001035 \\ \text{Ni, } 0.020 \div 59 &\div 2 \div 0.00001035 \\ \text{Pb, } 0.070 \div 207 &\times 2 \div 0.00001035 \end{aligned}$$

$$= 0.01703 \div 0.00001035 = 1,645 \text{ amp. seconds.}$$

Current available per day:

$$960 \times 60 \times 60 \times 24 \times 10 = 829,440,000 \text{ " "}$$

Anodes corroded per day:

$$\begin{aligned} 829,440,000 \div 1,645 &= 504,220 \text{ grams.} \\ &= 504.220 \text{ kilograms (4)} \end{aligned}$$

$$(5) \text{ Gold deposited} = 563,729 \text{ "}$$

$$\text{Gold dissolved} = 504,220 \times 0.603 = 304,045 \text{ "}$$

$$\text{Deficit in gold in the plant per day} = 259,684 \text{ " (5)}$$

(6) Weight of anodes:

$$960 \times 4 \times 17.5 \times 5 \times 10 = 3,360,000 \text{ grams.}$$

$$= 3,360 \text{ kilograms.}$$

$$\text{One-tenth scrap} = 336 \text{ "}$$

$$\text{Weight corroded} = 3,024 \text{ "}$$

Days to corrode them:

$$\frac{3.024}{504.22} = 5.93 = \text{practically 6 days.} \quad (6)$$

(7) Average time of treatment, removing one-sixth each day:

$$(1 + 2 + 3 + 4 + 5 + 6) \div 6 = 3.5 \text{ days.} \quad (7)$$

(8) Value of gold in plant is, in regular running, value of cathodes for all the time plus value of anodes for $3.5 \div 6 = 58$ per cent of the time.

Value of cathodes:

$$960 \times 0.1 \times 19.2 \text{ (sp. gr. gold)} \times 6 \times 10 \times 0.729 = \$80,578$$

Value of gold in anodes:

$$3,360,000 \times 0.603 \times 0.729 = 1,477,012$$

Average value of anode gold under treatment:

$$1,477,012 \times (3.5 \div 6) = 861,590$$

Sum of cathode gold continually in stock and average value of anode gold under treatment:

$$\$80,578 + \$861,590 = \$942,168$$

$$\text{Interest per annum at 6 per cent} = 56,530$$

$$\text{Interest charge per day} = 155$$

Interest charge per kg. of anode refined:

$$\$155 \div 504.22 = \$0.31 \text{ per kg.}$$

Interest charge per kg. of gold under treatment:

$$\$155 \div 304.045 = \$0.51 \text{ per kg.} \quad (8)$$

THE VOLATIZATION OF SILVER AND GOLD.

It is known that both of these metals can be vaporized; it can easily be done in the electric arc. If they are placed in a vacuum, in quartz vessels, they show signs of metal vaporizing at 680° and $1,070^\circ$, respectively, although what vapor tension this corresponds to we do not exactly know, but we can surmise it to be a small fraction of a millimeter. If heated still higher in a vacuum, they show the phenomenon of ebullition, or boil, at $1,360^\circ$ and $1,800^\circ$, respectively, although here again we do not know what pressure this corresponds to, except it is the pressure of the melted metals above the spot where the vapor commences to form beneath the surface, which might be 5 to 10 millimeters of melted metal, say 10 millimeters of mercury, if the bath of metal were shallow. From these data, obtained by Schuller, Kraft and Bergfeld, it is estimated that the boiling points of the two metals under atmospheric pressure are $2,040^\circ$ and $2,530^\circ$, respectively, on the assumption that the temperature interval between first signs of vaporization in a vacuum and boiling in a vacuum is equal to the interval between the latter temperature and the ordinary boiling point. (This is said to be true of mercury.)

O. P. Watts has estimated the boiling point of silver and gold as $1,850^\circ$ and $2,800^\circ$, respectively, meaning probably at atmospheric pressure; but his estimate is based on such assumptions that they cannot lay claim to as much accuracy as the data and estimates above cited.

If we go back to the very probable rule, that at equal fractions of the normal boiling points, expressed in absolute temperatures, metals have the same vapor tensions, we can compare silver and gold with mercury, whose vapor tension is known through a wide range, and get quite probable values for the vapor tensions of these metals through a large range of temperature. The following table is from nearly zero tension to about the temperature at which ebullition is noticeable in a vacuum:

<i>Tension of Vapor, m.m. of Hg.</i>	<i>Mercury, C°.</i>	<i>Lead, C°.</i>	<i>Silver, C°.</i>	<i>Gold, C°.</i>
0.0002	0	625	729	942
0.0005	10	658	766	987
0.0013	20	691	802	1,031
0.0029	30	724	839	1,075
0.0063	40	757	876	1,120
0.013	50	790	913	1,165

0.026	60	822	949	1,209
0.050	70	855	986	1,254
0.093	80	888	1,023	1,298
0.165	90	921	1,059	1,343
0.285	100	954	1,096	1,387
0.478	110	987	1,133	1,432
0.779	120	1,020	1,169	1,476
1.24	130	1,053	1,206	1,520
1.93	140	1,086	1,243	1,565
2.93	150	1,119	1,280	1,611
4.38	160	1,151	1,316	1,654
6.41	170	1,184	1,353	1,699
9.23	180	1,217	1,390	1,743

Inspecting the above table, we see that apparently about 0.0002 m.m. of mercury tension is sufficient to make a metal show signs of vaporization. The corresponding temperatures at which silver and gold show 0.0002 m.m. tension are, from the above table, 729° and 942° , respectively, whereas it is said to have been observed for these metals at 680° and $1,070^\circ$. The divergence is not wide, considering the lack of exact data involved.

Mercury is said to show ebullition in a vacuum at 180° , lead at $1,250^\circ$, silver at $1,360^\circ$ and gold at $1,800^\circ$. From the above table we see these metals having the same vapor tension at 180° , $1,217^\circ$, $1,390^\circ$ and $1,743^\circ$, respectively. The agreement is encouraging.

The table in continuation is for temperatures from those causing ebullition in a vacuum to those required to boil the metals at atmospheric pressure:

<i>Tension of Vapor, m.m. of Hg.</i>	<i>Mercury, C°.</i>	<i>Lead, C°.</i>	<i>Silver, C°.</i>	<i>Gold, C°.</i>
9.23	180	1,217	1,390	1,743
14.84	190	1,250	1,427	1,788
19.99	200	1,283	1,463	1,832
26.35	210	1,316	1,500	1,877
34.70	220	1,349	1,537	1,921
45.35	230	1,382	1,574	1,965
58.82	240	1,415	1,610	2,010
75.75	250	1,448	1,647	2,055
96.73	260	1,480	1,684	2,099
123.	270	1,513	1,720	2,144
155.	280	1,546	1,757	2,188
195.	290	1,579	1,794	2,233
242.	300	1,612	1,830	2,277
300.	310	1,645	1,867	2,322
369.	320	1,678	1,904	2,366
451.	330	1,711	1,941	2,410
548.	340	1,744	1,977	2,455
663.	350	1,777	2,014	2,500
760.	357	1,800	2,040	2,530

For tensions of metallic vapors over 1 atmosphere, such as may easily occur in high temperature work, particularly in electric furnaces, the following data may be useful:

<i>Tension of Vapor, Atmospheres.</i>	<i>Mercury, C°.</i>	<i>Lead, C°.</i>	<i>Silver, C°.</i>	<i>Gold, C°.</i>
1.0	357	1,800	2,040	2,530
2.1	400	1,951	2,197	2,722
4.25	450	2,116	2,380	2,945
8.	500	2,280	2,564	3,167
13.8	550	2,445	2,747	3,390
22.3	600	2,609	2,931	3,612
34.0	650	2,774	3,114	3,835
50.	700	2,938	3,298	4,057
72.	750	3,103	3,481	4,280
102.	800	3,267	3,665	4,502
137.5	850	3,436	3,848	4,725
162.	880	3,525	3,958	4,858

The last table may not be of much immediate practical value, but it is interesting scientific information. The preceding tables are, however, technically and commercially important. They point particularly to the wastefulness of melting silver or gold in open furnaces where furnace gases pass over the metal. Such gases, at temperatures above 700° for silver and 950° for gold, i. e., even passing over *unmelted* metal, can cause volatilization and loss of weight, because they evaporate the metal on exactly the same principle that a current of dry air evaporates ice or water. They also explain why silver volatilizes with lead in the cupellation operation. At 1,000° C. lead has a vapor tension of about 0.62 m.m. of mercury, and silver about 0.07 m.m., and, therefore, a considerable loss of silver is sure to occur with the lead vapors passing off. Gold at the same temperature has only 0.0007 m.m. tension, and, therefore, proportionately less of it is lost, say only one-fiftieth as much as the silver loss, reckoning from the proportionate tensions and the relative densities of the two vapors.

In calculating such metallic vapor losses it is important to remember that the metals are monatomic when in the state of vapor, and that the molecular weights of their vapors are simply their atomic weights. The hypothetical weight of a cubic meter of such metallic vapor at standard conditions, 0° C. and 760 m.m. pressure, is, therefore,

$$0.09 \text{ kg.} \times \frac{\text{atomic weight}}{2},$$

and from this theoretical datum the weight of any volume at any temperature and any tension can be calculated.

Illustration: Calculate the weight of silver vapor contained in 1 cubic meter of furnace gases, if saturated with silver vapor and at 1,100° C.

Solution: Since the tension of silver at this temperature is 0.28 m.m., the question resolves itself into this: What is the weight of 1 cubic meter of silver vapor at 1,100° and 0.28 m.m. pressure? One cubic meter at standard conditions would be $0.09 \times (108 \div 2) = 4.86$ kilograms; therefore, at these given conditions, it contains:

$$4.86 \times \frac{273}{1,100 + 273} \times \frac{0.28}{760} = 0.0035 \text{ kg.} \\ = 3.5 \text{ grams.}$$

It is true that the silver vapor, being heavy, mixes slowly with the furnace gases, but, nevertheless, the gases rushing over and coming in contact with the silver may become nearly saturated with this vapor, and carry considerable away. In the Bessemerizing of copper matte to blister copper, by blowing air directly through it, as much as 30 per cent of all the silver present may be thus vaporized from the bath as soon as the silver has taken the metallic form.

Every smelter and refiner of the precious metals should be familiar with these facts, and draw conclusions from them useful to the conduct of his business.

The specific heat of these metallic vapors is 0.225 per cubic meter (calculated to standard conditions), and the latent heat of vaporization is approximately twenty-three times the normal boiling point expressed in absolute temperature for one atomic weight of the metal—as explained in Part I. of these calculations:

For silver and gold we would have the latent heats:

Ag, 23 (2,040 + 273)	= 53,200 Cal. per 108 kg.
"	= 493 " 1 kg.
Au, 23 (2,530 + 273)	= 64,470 " 197 kg.
"	= 327 " 1 kg.

The above latent heats of vaporization are for boiling at

normal atmospheric pressure; for vaporization at other pressures and corresponding temperatures, correction must be made for the difference in specific heats of the metallic vapor and liquid metal.

The next instalment of these calculations will deal with the metallurgy of zinc, mercury and cadmium.

Notes on Metallurgy and Electrochemistry in Great Britain.

(By Our Special Correspondent.)

THE ALUMINIUM SITUATION.

An extraordinary general meeting of the shareholders in the British Aluminium Co., Ltd., have resolved to split their £10 conversion shares into two shares of £5 each, one to be a 7 per cent preference share and the other an ordinary share.

In view of the collapse of copper prices, the remarks of Mr. J. D. Bonner, the chairman, are of considerable interest. He said they were all no doubt aware of the demoralization of the metal markets of the world last summer, consequent on the slump in copper and the serious fall in metal prices generally, which brought to an abrupt termination the little boom in aluminium. Notwithstanding, it was estimated that the profits in 1907 would not fall materially below the £153,000 which they made in the previous year. They brought forward over £34,000 from 1906, so that they would have a very large disposable balance. It was their intention to deal with this upon the same conservative lines that they had proceeded upon in recent years, and after making a large appropriation to reserve fund, etc., and paying 7 per cent upon their ordinary shares, to carry forward an amount somewhere in the neighborhood of £50,000. They expected this year, now that they had started producing at the works at Leven, and at the Norwegian works, to produce about twice as much aluminium as they did last year. Although the price was at present only about £100, yet, if they succeeded in disposing of the whole of the increased production, which he was hopeful of doing, there should not be any material shrinkage in their profits, especially as some increase could be confidently counted upon for their investments. At all events, they had a larger tonnage of aluminium sold for forward delivery than ever before.

They had suffered an irreparable loss by the death of Lord Kelvin. Lord Kelvin was always keenly interested in the aluminium industry, and rendered eminent services in connection with its introduction by the company into this country. They who had been associated with him in its development and had had the benefit of his splendid intellect, could not but regret that they would lose the advantage of his guidance. Fortunately Mr. Morrison, with Lord Kelvin's full approval, became technical adviser jointly when Lord Kelvin was still with them. Their company was not merely an aluminium and manufacturing company, but was also a great power company, which in almost the immediate future, when all their great power schemes were completely developed, would have at its command something like 60,000 hp. They had had the advantage of their Foyers power for some years. Their Norwegian power was not so important, but it was a very cheap one. The Leven power, which was their largest, was, on account of its uniformity and location, one of the finest powers in the world. At Loch Leven they were building what was practically a small harbor, so that steamers of large tonnage could be able to approach at all times to within a few hundred yards of the works. Cheap freights were thus assured for all materials required, as well as for the material produced. They were also proceeding with the building of a village to give accommodation for 6,000 to 8,000 people, who would be necessary for the utilization of the power. They had a very valu-

able asset at Leven and were looking forward to the time when the large sum which they had expended upon it became productive, for they were not even taking credit for the interest during the constructive period, although authorized to do so under their Parliamentary powers. The scheme was costing materially more than they originally anticipated, and was taking longer to finish. This had caused great disappointment to the directors, as they had to promote a bill in this session of Parliament for an extension of time to complete the works. A year ago he mentioned that they were quite alive to the possibility of the demand for the prices of aluminium proving insufficient to warrant their employing in its production the whole of the power they had in prospect when it first became available. At any rate, for some years they would have to utilize the Orsieres power for other production, and at the present time negotiations with a Continental electrochemical company were in progress for that end. The shareholder would be prepared to hear that, in consequence of the large expenditure they incurred, they would want more money; but they still had over £300,000 to receive in respect of their last issue of conversion shares. They would, however, take advantage of any favorable opportunity to issue the £200,000 6 per cent preference shares they agreed to last spring; these formed part of a total issue of £300,000 6 per cent preference shares, of which £100,000 were placed some years ago, and they had behind them £1,000,000 of junior capital. Any other capital required would be raised by rearranging and enlarging the debenture debt and capital would stand at just over £2,000,000, the greater part of which was yet to become profit-earning. They would not only have this 60,000 hp., but other assets of great value. They owned the estate and village of Foyers, the village of Leven, their valuable and important French Bauxite investment, their carbon works and aluminium works at Larne, which cost over £100,000, and their large rolling mills in Staffordshire, which, owing to increasing demands for sheets and other manufactured products, they were compelled to still further enlarge. The only intangible asset in their balance sheet was good will, which had been reduced to £93,000, and which would be further reducible by the last year's profits, and would be gradually wiped out altogether. Their assets were not only valuable, but they might be counted upon to yield an income sufficient to assure them very substantial dividends.

BRITISH ELECTROCHEMICAL PATENTS EXPIRING IN 1908.

According to my usual custom I give herein details of inventions patented in 1804, which, having survived their full term, expire this year.

No. 835. Hargreaves and Bird.—"Improvements in the construction of electrolytic apparatus and in the application thereof in oxidizing, chlorinating and analogous processes."

This relates to the treatment of sewage, paper pulp, etc., requiring to be subjected to oxidization, chlorination, etc., and embraces the employment of apparatus constructed on the principle of Spec. No. 18,871, 1892.

For oxidation of sewage in which Cl. is present, for example, a series of cells may be used, the sewage flowing through each in turn, walls of cell composed partly or wholly of a permeable material in conjunction with a cathode of wire gauze or perforated metal; immersed in sewage is an anode of carbon, anode is made to divide cell into flow and return passages, cell may be enclosed in a chamber through which cold or hot air or steam circulates. Cl. liberated at anode combines with H in organic matter and forms HCl, O being liberated; HCl immediately decomposes, H being liberated from cathode and Cl regenerated.

Where direct oxidation is required H_2SO_4 or HNO_3 or salts from which they are derived may be added to the material under treatment. For bleaching paper pulp NaCl is employed instead of air acid.

It is further claimed that the apparatus may be used for

bleaching cloth with the addition of guide rollers, and may also be used in the preparation of aniline dyes and organic acids, etc.

No. 9,285. Kellner.—Is entitled "Improvements in or relating to electrodes and method of manufacture."

This invention has for its object the construction and arrangement of electrodes, which can be made of any desired size and of any conducting material capable of resisting the action of the ions, and which, at the same time, constitute a perfectly tight closure, and have also the great advantage that in consequence of the "point-action" which takes place by their use, they can be worked at a much greater current density than other electrodes.

No. 12,221. Acheson.—Is entitled "Improvements connected with electrical furnaces," and its object is an improved construction and arrangement of mechanical parts of furnaces for the purpose of utilizing the current more economically and thus securing a cheapening of the product.

One of the objects of the invention is to provide a furnace wherein the current is restricted to a great extent to a cone in its passage through the furnace, while the material to be operated upon is arranged in the furnace so as to receive the heat energy from the core in lines diverging from the direction of the path of the current in contradistinction to those furnaces in which the material being operated on is intermingled with the conducting medium.

Also the core is of a relatively lower resistance than that of the material being treated, so that little, if any, of the material being treated carries the current.

The core may be of various substances, solid or granular; granular carbon is preferable, the size of grain varying according to size of furnace; in furnace 8 feet in length and maximum energy 100 kw., the diameter of core being 10 inches, grains would be about 3/16 inch diameter.

No. 14,987. Solway.—Is entitled "Improvements in or relating to the separation of caustic alkalis from the liquors obtained by the electrolysis of alkaline salts."

In order to effect a separation of the caustic alkali from the chloride the mother liquor may be subjected to evaporation whereby, when the solution has reached a certain degree of concentration, the salt becomes insoluble in the caustic alkali and precipitates.

Instead of evaporating the mother liquor resulting from electrolysis, there is poured into the same a solution of caustic soda of about 40° Beaumé. Produced by a prior operation, this addition has the effect of causing the whole of the salt present in the liquor to be precipitated and produces a solution practically free from NaCl, and which can therefore be readily evaporated by the triple effect apparatus.

The quantity of liquid that can be thus obtained is very small; the greater portion remains as soft mud; if attempts be made to take out the separated salt, it is found to be impregnated with soda solution to such a degree that the result is nil. To overcome this the mixture of salt and caustic liquor is placed in a vessel provided with a double casing to enable it to be heated by steam, and with a false bottom for keeping back the solid portion and allowing only the liquid to pass through, the whole is heated to about 100° C., after which there is poured on top of the mixture a layer of saturated salt water of equal volume to the caustic solution. On opening a discharge cock at the bottom of the vessel a displacement of a molar nature is produced, the caustic solution is expelled in successive horizontal layers and is replaced by the salt water without any mixing taking place. By this means practically the whole of the caustic solution can be obtained without dilution, and a mother liquor is also obtained for a succeeding operation.

No. 14,988. Solway.—Is entitled "Improvements in electrolytic cells," and remarks that a great drawback of all electrolytic cells is their small output in relation to surface area, due to the resistance of the electrolyte. This invention has refer-

ence to the reduction of the resistance by the use of electrolyzing surfaces formed of very thin electrodes placed side by side instead of opposite to each other, or face to face, with intervening spaces as before. Thus, when using strips of platinum insulated on their two sides or surfaces, the strips are pressed together like the leaves of a book, so that only their edges serve as conducting surfaces. In this manner there may be built up a block or slab, which, when seen from one side, will show an alternating arrangement of conducting and insulating lines, constituting, it may be, a plane or flat surface, and forming what is termed an electrolytic table, even numbered strips being connected to one pole and odd strips to the other; the total section of each strip acts as a conductor, but only the edge acts in electrolysis; edge may be made of Pt, and remainder of a cheaper metal.

As electrolysis effected by this means takes place with great intensity, the liquid must be quickly renewed, the table may be inclined and liquid arranged to flow over in a stream; surfaces may be in tubular form and liquid subjected to pressure; or centrifugal action may be employed.

A description is also given of a system of grooved covers for separating the products of electrolysis.

No. 15,276. Kiliani and Others.—Is entitled "Improvements in, or connected with, diaphragms for electrolytic purposes," and points out that diaphragms are at present made either of clay or porcelain, etc., which offer a great resistance to the current; or of thin sheets of soft, flexible material, such as parchment or asbestos, which have not sufficient mechanical strength unless supported.

The invention consists of supporting the parchment or asbestos, etc., by compressing it between two parallel series of laths, bars or rods of acid-proof material, the ends of the rods being fixed in frames and the frames built up into receptacles, etc.

The most important commercially is No. 20,259. Kellner (amended specification), entitled "Improvements in electrolytic apparatus for decomposing metallic salts," which forms the basis of the Castner Kellner electrolytic alkali process.

This invention has reference to an apparatus for the electrolysis of alkaline salts with the aid of a stationary mercury cathode, in which the amalgams formed by the electrolytic action has its location changed from the decomposing chamber, in which it is produced, to a combining chamber, in which it is decomposed and the cation combined with water, an acid or other body, by the shifting of a partition which can be moved to and fro in the mercury and serves to separate the two aforesaid chambers from each other. This partition is made in the form of a bell closed at its lower edge by a mercury seal and enclosing the decomposing chamber so that the amalgam formed in the latter is caused by the shifting of the bell to have its location alternately on one side and on the other side of the bell without itself changing its position, and thus is caused to become situated in the combining chamber, whilst the mercury on the other side of the partition, which was previously situated in the combining chamber, effects the amalgamation of the metal that is being separated by the decomposition of the electrolyte.

No. 24,541. Kellner.—Is entitled "Method of, and apparatus for, effecting electrolysis." This invention is designed to provide means for enabling the complete decomposition of metallic chlorides to be effected electrolytically with the practically complete utilization of the electrochemical equivalent of energy by means of vertically arranged, extremely simple, durable and reliable apparatus, without the use of a porous diaphragm.

The mercury cathode is employed in the form of narrow strips, which are formed by a system of channels arranged in a helical or zigzag path around the anode, whilst they are being continually freed from the cation they have taken up in their course.

The cathode consists of a spiral channel circulating around

a porcelain cylinder, the channel being of porcelain and formed in one with the cylinder containing mercury, which is pumped from the bottom to the top of the spiral and circulates around the cylinder to the bottom by gravity. The channel is also formed around the inside of the cylinder, and it is arranged so that the odd numbered convolutions of the helix are on the inner surface of the cylinders, while the even numbered ones are on the outside; the mercury passes from outside to inside by means of an opening in the cylinder wall.

Inside this cylinder there is situated an anode of cylindrical form, which is filled with salt in a solid state, to be decomposed; this dissolves and maintains the strength of the solutions. The whole is arranged in a vessel which contains the substance (water, or other fluid agent) with which the separated cation is to be combined, and which is closed by a cover having gas outlet and water-inlet pipes.

The containing vessel may be of iron and connected electrically to various points in the mercury channel, and also to the negative pole of the generator.

SOME RECENT IMPROVEMENTS IN THE WRIGHT MERCURY ELECTROLYTIC METER.

A paper in the *London Electrician*, by H. Stafford Hatfield, is deserving of attention.

After summarizing the general arrangement and construction, the original Wright meter, nature of changes in the electrolyte, investigation for new electrolyte, improvement in construction and method of manufacture, these are treated of in detail.

General Arrangement.—The current is divided between a low-resistance shunt in parallel with a circuit comprising an electrolytic cell and a high resistance in series. About 1 per cent of the current passes through the latter. The cell—a small glass tube—contains a mercury anode, an aqueous solution of a salt of mercury and a cathode of any metal which will not amalgamate. On this the mercury is deposited, and falls in very minute drops into a graduated tube from which B. T. U. can be read. Further structural details are then described.

The Original Wright Meter.—Mr. Stafford proceeds to point out how this, although apparently accurate, developed faults which appeared to be in consequence of errors in the disposition of the electrolyte. He explains, at some length, the nature of the required corrections, which will, perhaps, be found interesting to chemists. The instrument has evidently been designed with much forethought in regard to its stability; and experiments with various electrolytes made, the conclusions from which are given in the footnotes.

Nature of Changes in the Electrolyte.—It is stated that the electrolyte containing 10 per cent of mercurous nitrate and 1.1 per cent of free acid is stable at ordinary temperatures in the presence of mercury, and a possibly new view of the interference of electrolysis with chemical action is foreshadowed. The footnote here is misleading [*vide* "Elementary Chemistry"], and the use of the term "meta-stable" is very questionable. Moreover, the "balancing point" mentioned is the *alter ego* of the critical point of unstable equilibrium, and it would be well if some common system of nomenclature could be agreed on which would apply *mutatis mutandis* to all branches of chemical science.

THE PHYSICAL SOCIETY'S ANNUAL EXHIBITION OF APPARATUS.

On Friday evening, Dec. 13, 1907, the Physical Society, at the Royal College of Science, South Kensington, an exhibition of various scientific apparatus—this being the third anniversary—to which members of allied societies were invited. The whole was of interest and value, and the following features attracted special attention:

The Cambridge Scientific Instrument Co., Ltd., exhibited a good selection of their widely known instruments; Callender & Griffiths' bridge being particularly worth attention by reason of the new features and improvements it presents. They also

exhibited a potentiometer designed for thermo-electric work, which appears to embody several improvements, especially in regard to homogeneity of structure as far as possible. The company also showed a D'Arsonval galvanometer, Nernst lamp and scale, an improved form of milli-voltmeter, a Duddell's patent sensitive thermo-ammeter, etc.

Messrs. Cassells had Reeves' patent distance measurer, described as a new instrument for measuring distances without calculation, a gradient telemeter level, and others which need not be specified.

Messrs. Crompton & Co's exhibit included a portable slide wire, having good points; a standard potentiometer of modern disposition; a portable voltmeter with self-contained resistances; a universal shunt box of the Ayrtton-Mather type, and a portable pyrometer for boiler testing.

Messrs. Elliott Bros. exhibited Harrison's universal photometer. They also had a new pattern P. O. Wheatstone bridge; an improved meter bridge; a "Century" mains test set—most useful; a fault localizing bridge (Murray's loop test); latest P. O. pattern Wheatstone transmitter-receiver-perforator, and several galvanometers, etc., well deserving attention. Their new "Die Castings" require further elaboration, but their speed indicators will, no doubt, be very useful to those in charge of motor cars.

Messrs. Everett, Edgcombe & Co., Ltd., also exposed a flicker photometer with inclined screen and an inkless synchronized recorder; the Hamilton multicellular electrostatic voltmeter; a frequency indicator of resonance pattern; a direct-reading resistance bridge; a combined standard ammeter and voltmeter, and a portable astatic wattmeter were also shown.

Messrs. Evershed & Vignoles, Ltd., exhibited high-range and low-range meggers deserving attention; a bridge megger for workshop use; a combined ammeter and voltmeter for direct currents, and a cell tester for accumulators.

Messrs. A. Hilger, Ltd., had their quartz spectrometer and specimen prints and enlargements; a large wave-length spectroscopic, and the Fabry & Perot interferometer. This exhibit deserved especial attention.

Messrs. Ross, Ltd. This firm's most noteworthy feature was a photo-micrographic camera of new construction with Nernst lamp and standard microscope.

Messrs. Alexander Wright & Co., Ltd., displayed the "Simman-Abady calorimeter," an instrument designed for the purpose of continuously and automatically indicating and recording the potential energy of gas in calories.

I regret that considerations of space compel me to omit mention of other exhibits.

A QUIET MONTH.

From the literary point of view, January was, in English electrochemical and electrometallurgical circles, a singularly quiet month. No meeting of the Faraday Society was held. The Institution of Mining and Metallurgy concerned themselves with three papers of a purely geological nature. Sister institutions, such as the Civils and Mechanicals, did not touch upon metallurgical matters. Save for declining prices in the metal trades (where the unsettled condition of the shipbuilding industry is a depressing factor), and an important meeting of the shareholders in the British Aluminium Co., your correspondent has little to chronicle, save details of patents expiring this year. One or two are of great importance. Others, however, suggest that the unfit occasionally survive.

MARKET PRICES FOR JANUARY.

Tin.—On Jan. 2 the price of tin was £120.15 per ton; it fell to £118.12 on the 3d, rose to £123.5 on the 7th, fell to £121.8 on the 8th, and with slight fluctuations rose to £126.5 on the 14th, falling to £123 on the 17th, rising to £125.12 on the 20th, falling again to £123.18 on the 22d, rising to £125.5 on the 24th; it reached £123 on the 28th.

Copper.—Has not shown any marked variation during Jan-

uary. Opening at £61 to £62 per ton, it rose to £62.15 on the 7th, and after a fall to £61.15 on the 8th, rose steadily until on the 15th £64.5 was reached, after which date it again fell to £62.15 on the 17th. Rising to £63.10 on the 20th, it fell to £61.8 on the 27th and reached £62 on the 28th.

Pig Iron.—Cleveland fell nearly continuously during the month. Opening at about 48/4 per ton, it rose to 48/10 on the 6th, fell to 48/2 on the 14th, rose to and remained at 48/6 during the 15th, from which it fell to 47/7 on the 23d, and rising to 47/10 on the 24th, reached 47/6 on the 28th.

Scotch Pig Iron.—The price of this was 57/6 per ton on the 6th of January, at which it remained steady until the 16th, falling to 57/- on the 7th; this price remained until the 22d; on the 23d it again fell to 56/9, at which it remained until the 28th.

Hematite.—Was 65/10 on the 31st of December, 1907, and by the 6th of January, 1908, had fallen to 64/6; it remained at this price until the 13th, fell to 63/10 on the 14th and remained steady until the 16th, from which date it fell to 61/10 on the 20th, remaining at this price until the 22d; it fell to 60/10 on the 23d, and was steady at this until the 28th.

English Lead.—Opened at about £15 per ton, and with the exception of a fall to £14.12 on the 9th, it remained at from £14.18 to £15.3 during the whole of the month.

The price of antimony for the end of the month was £35 to £36 per ton.

The chemical market at the end of the month was as follows: Ammonia sulphate, £12 per ton; copper sulphate, £23.5 per ton; bleaching powder, 35 per cent, £4.10; white caustic soda, 77 per cent, £11.2.6 per ton; benzole, 90 per cent, 7d. per gallon; carbolic acid liquid, 97 to 99 per cent, 1/1 per gallon; creosote, ordinary good liquid, 2½d. per gallon; naphtha solvent, 90 per cent at 160° C., 11d. per gallon; pitch, £11.6 per ton; shellac, £6.2.6 per cwt.

RECENT METALLURGICAL PATENTS

Iron and Steel.

Treatment of Chilling Iron with Nickel.—R. C. Totten (878,691, Feb. 11) describes the following process of treating chilling iron, *i. e.*, cast iron having a percentage of combined carbon (½ per cent or more) sufficiently large to give a chilled surface when cast in a chill mold. It is based on the affinity of nickel for the combined carbon, and on the fact that by varying the percentage of nickel to combined carbon the depth of chill may be regulated. In general the amount of nickel alloyed with the iron is made to follow approximately the proportion of combined carbon in the iron; for instance, if there is 1 per cent of combined carbon in the chilling iron, 1 per cent of nickel may be used. But by varying the proportion of nickel, the depth of the chill may be varied, since the nickel has a tendency to reduce the chilling properties of the combined carbon. For instance, if a chilling iron containing a certain percentage of combined carbon has added thereto, say, 1½ per cent nickel and produces a casting having a chill, say, 1 inch thick, then by using exactly the same iron and increasing the percentage of nickel, the depth of the chill will be decreased, or, by decreasing the quantity of nickel, the depth of the chill will be increased. This possibility of regulating the depth of the chill by varying the quantity of nickel used is of special importance in the utilization of scrap from car wheels, chilled rolls, etc. If such scrap is remelted and recast, there is a large increase in the proportion of combined carbon, giving an abnormally deep chill and rendering the article very brittle. By the use of nickel a chill of the desired depth is obtained and the strength and ductility of the nickel are greatly increased.

Hardening Cast Iron.—For hardening cast iron, G. H. H. Emmet (878,053, Feb. 4) uses a compound consisting of 8 pounds flower of sulphur, 1 pound dry red lead, 4 ounces lamp black. These ingredients are ground in a mill, then run

through a sieve and well mixed together. For general purposes, 1 pound of the compound is added to 30 pounds of molten iron; for rock crusher castings (chilled) 1 pound of compound to 40 pounds iron; for sheaves (not chilled) 1 pound of compound to 25 pounds iron; and for sheaves with soft core 1 pound of compound to 30 pounds of iron.

Copper.

Treatment of Mine Waters.—To recover metals from mine waters, etc.—in general, from solutions containing the metal values in very small quantities—H. M. Crowther (877,912, Feb. 4) employs evaporation and filtration by capillary action, with precipitation of the metal in form of a solid compound. For instance, in the case of a liquid containing dissolved copper salts, like tailings water, which also contains much indissolved sediment in suspension, he proceeds as follows. A large shallow cone, open at the large end, is made of porous canvas or cloth and filled loosely to a depth of about 12 inches with broken bricks, cotton waste or other absorbent material, mixed with small bits of scrap iron (which are to act as a precipitant). The lower (small surface) point of the cone is then slightly submersed in the solution, when capillary action will draw up the copper solution and filter it at the same time. The great extension of evaporating surface results in increased concentration and the copper will be precipitated as metal by the iron, or copper salts will crystallize out. Another illustration of the process is as follows: A common absorbent building brick is saturated with a solution of sodium carbonate and partially dried out and its end is slightly submersed in the liquid containing a small percentage of a copper salt. In this case carbonate of copper will be precipitated in the pores of the brick.

Gold and Silver.

Slimes Filter.—Charles Butters, who is so well known through his intimate connection with the development of the cyanide process, patents (879,080, Feb. 11) the following process of treating slimes. While this process, as used at the cyanide plant of the Combination Mill, at Goldfield, Nev., has already been described at length and illustrated in our Vol. V., p. 88, it is interesting to sum up here the inventor's own description from his patent. In Fig. 1 the bottom of the tank 1 has an outlet 2, provided with a closure 3. In the upper portion a filter frame 6 is supported with the tubes 7 and 8. Tube 7 is deflected horizontally after it passes into the interior of the frame 6 and has perforations on its lower side (as indicated by dotted lines). Tube 8 passes to the bottom of frame 6 and is deflected horizontally and has perforations upon its upper side (as indicated by dotted lines).

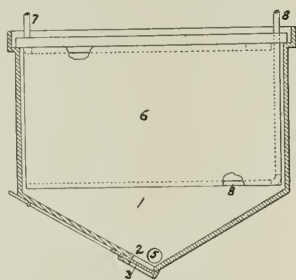


FIG. 1.—SLIMES FILTER.

Pipe 5 is provided for introducing and removing the slimes and solutions into and from the vat.

The slimes, after having been prepared and mixed with a quantity of lime or alkali, are discharged into vat 7 until the filter 6 is submerged. By exhausting the air from pipe 8, a vacuum is formed in the interior of the filter and maintained at as high a degree as the altitude of the locality where the process is carried on will permit. This causes a layer of the slimes to be deposited upon the surface of filter 6. The vacuum is then reduced to approximately 6 inches of mercury [sufficient to hold the layers of slime attached to the filtering

surfaces]. The [balance of the] slimes is now discharged from vat 1 and the latter filled with cyanide solution. The vacuum is then again increased to the maximum, whereby the cyanide solution is drawn through the cakes of slimes. This is followed by again reducing the vacuum and discharging the cyanide solution from the vat into a receptacle where it can be stored for future use. The vat is next filled with water and the vacuum increased, whereby the remaining values in the slimes are withdrawn through the filter. The final operation consists in admitting air through pipe 8, and water through pipe 7 into the interior of the filter, whereby the cake of slimes is discharged therefrom. The exhausted slimes may be discharged from the tank by opening the closure 3. In localities where water is plentiful, the cake may be discharged without the use of air.

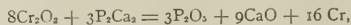
Filter.—The Ridgway filter has already attracted considerable attention. Those interested in it will find the details of construction described in a recent patent granted to George Ridgway, of Kalgoorlie, Western Australia (877,000, Jan. 21). The general idea of the filter is indicated by the first claim which refers to "a device comprising in combination a plurality of tanks arranged in circular order, a filter, a frame therefor provided with a roller, a track surrounding said tanks and provided with raised portions, said track being adapted for engagement by said roller to support said frame and raise and lower said filter out of and into said tanks, and means for moving said filters abreast of said tanks."

Aluminothermic Method.

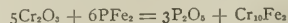
Modification of Thermit Process.—K. A. Kuehne has formerly proposed to modify the well-known Goldschmidt process of reducing refractory oxides by means of powdered aluminium in so far as to use a mixture of aluminium with chlorates and perchlorates instead of pure aluminium. This he has recommended for the production of pure metals or metalloids in fused state, which cannot be thus obtained by reduction with aluminium alone. He now (878,210, Feb. 4) states that: instead of the chlorates and perchlorates he may employ other substances which easily give off oxygen, such as peroxides. In the original Goldschmidt process itself, barium peroxide is used as ignition powder. But Kuehne proposes to use the peroxide in larger quantities, i. e., to use a mixture of aluminium and peroxide. Barium peroxide, lead peroxide and sodium peroxide may be used; in the same manner, persulphates, like sodium persulphate, may be employed. In order to get a highly fluid slag, so as to collect all the reduced metal on the bottom of the crucible, fluorspar, lime and the like are added.

Productions of Metals or Alloys from Refractory Compounds.

Phosphides as Reducing Agents.—F. von Kuegelgen and G. O. Seward (878,966, Feb. 11) propose the use of calcium phosphide, aluminium phosphide, iron phosphide, etc., as reducing agents. For instance, the reduction of chromium from chromic oxide is carried out by means of calcium phosphide according to the equation



both calcium and phosphorus acting as reducing agents. On the other hand, if iron phosphide is used, then the reaction is



ferrochrome being produced. In this case the phosphorus alone acts as reducing agent. The heat of reaction is very different in different cases and in many cases the heat of reaction will have to be supplemented to a greater or less degree by other heating. In some cases the reaction will continue by the heat of the reaction after being started by the supplementing heating.

High Temperature Burners.

Air-Acetylene Burner.—John Harris, of Cleveland, Ohio, has formerly patented an air-acetylene burner (as distinguished from the oxy-acetylene burner), in which air and acetylene gas are thoroughly mingled in a mixing tube and the mixture ignited at the outlet end of the tube. The expanded burning mixture is prevented from dying away or blowing out as the air pressure is increased. However, this method seems to have met with some difficulties, since in his latest patent (878,461, Feb. 4) Harris modifies this design and provides a supply of oxygen at the base of the air-acetylene flame so as to increase the intensity of the flame and assure its adherence to the end of the mixing tube.

Cutting Metals.—In our Vol. V., p. 308, an illustrated article by M. U. Schoop was published on a new art of cutting metals, which is essentially based on the use of the oxy-acetylene or oxy-hydrogen or oxy-illuminating gas burner with an additional small tube supplying separately oxygen for burning and cutting the metal. A special burner for this purpose is the object of a patent of E. Ganthier and C. Rodrigues-Ely (874,666, Dec. 24, 1907), in which the quantities of gas are led in several independent streams to the work to be cut. How this special burner works out in practice we do not know. But it is a fact that the art of cutting metal plates by burners of this general type is finding considerable applications and great success in Europe, while it is still almost unknown in this country.

Regenerative Furnace.

Reversing Valve.—John B. Nau (878,306, Feb. 4) patents a reversing-valve system for regenerative furnaces, shown in Fig. 2, where *a* is a vertical section, *b* a section on line I-I, and *c* a plan view on line II-II. The valve system is enclosed within a metal casing 1, set directly over and surrounding flue openings, of which 2 leads to the left-hand regenerator, 3 to the smoke-flue, and 4 to the right-hand regenerator. The casing 1 is divided into three compartments, of which the lower ones 5, forming the valve chamber, are separated by a partition 6 in such a way that each chamber 5 will enclose one regenerator and one smoke-flue opening. Through their top partition each chamber 5 communicates by means of an opening 7 with the third compartment, the gas or air chamber 8. Each opening 7 is located directly opposite one of the smoke-flue openings 3. The gas chamber 8 is provided in its roof with a gas inlet opening 9 and at its two ends with cleaning doors 34.

Each valve chamber 5 is provided with a reversing valve 10, that by means of one or more hollow or solid spindles 11 can be moved up and down between its upper valve seat 12 and its lower valve seat 13. The upper valve seat 12 placed around and below opening 7 is made of a hollow-walled, water-cooled shell. The lower water seal is formed by a water trough 13, surrounding the smoke-flue opening 3. In order to prevent the passage of gas from one chamber to the other, a flange 35 is provided under partition 6. It reaches to a certain depth into the water below. The circularly-shaped reversing valve 10 is formed of a partition 14, surrounded on its rim by a water trough 15, normally filled with water to the level of the overflow 16. The removable iron ring 18, which is bolted to the circular flange 17, is meant to receive the first impact of the flame, so that the valve proper is protected against deterioration and possible cracking.

The valve is operated and regulated by means of the wheel 23. When the two valves are placed at the same level in their intermediate positions, they form both water seals with their upper valve seats, but not with their lower ones, thereby effectively preventing gas from entering the furnace, and yet leaving below free communication between the regenerator flues and the smoke-flues. With this arrangement of the valve system the two ends of the furnace can be, with the ordinary operation of the valves, put in communication with the smoke-stack, without in any way emptying the lower water seal of its water and without admitting any gas to the valve.

When starting the operations of the valves from their intermediate positions, one valve will move upward the same amount that the other one will move downward. Of course, when the latter valve has reached its lowest position, a sufficient passage will have been established between itself and its upper valve seat for the necessary amount of gas to enter the furnace. But meanwhile the other valve, being placed in its upper position, will have opened a much larger passage for the products of combustion to pass between the valve and its lower valve seat on their way to the smokestack. Thus an excellent draft is always assured, whatever the positions of the valves. Under these circumstances it is possible to regulate the admission of gas to the furnace with the valve itself, instead of doing it with a valve controlling opening 9, as is done in other systems. Hence, when using the valve system with gas, the regulating valve with all its accessories, controlling opening 9, can

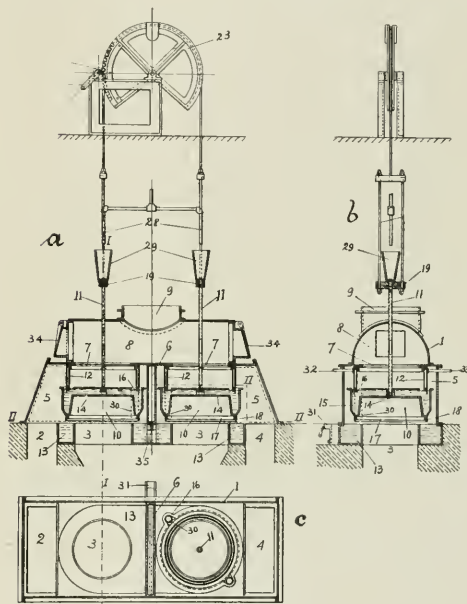


FIG. 2.—REVERSING VALVE FOR REGENERATIVE FURNACES.

be omitted. When using it with air, the whole gas chamber 8 with all its parts, such as gas inlet opening 9, cleaning doors 34, etc., can be omitted altogether. The outside air will then enter directly through that opening 7 which is kept open.

Cement.

Pulverizing Limestone.—In ordinary practice of cement manufacture the limestone is first crushed and then ground to the desired fineness. L. K. Forsythe (878,515, Feb. 11) endeavors to reduce the cost of this method by heating the rock to about 400° F. (which is below the temperature at which CO₂ is driven off). By then plunging the limestone into water, or by throwing water on the same, the limestone is rendered very pliable, so that it can be easily crushed and ground, the output of the mills being greatly increased.

Induction Furnace.—An excellent illustrated summary of the different designs of electric induction furnaces was recently given in a paper of Chief Engineer Victor Engelhardt before the Berlin Electrical Society. On account of limitations of space, we reserve a full report of the same for our next issue.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

Fixation of Atmospheric Nitrogen.

Arc Between Refractory Oxides.—Experimental investigations on the fixation of atmospheric nitrogen have become quite fashionable in Germany, as will be seen from the following abstracts of several recent interesting papers. E. Rasch (*Zeit. f. Elektrochemie*, Oct. 11) discusses the oxidation of atmospheric nitrogen in an arc between "conductors of the second class" (magnesia, thorium oxide, etc.). In early experiments on this subject he had hoped this would become a new useful source of light, but he soon found that the nitrous fumes formed were a great disadvantage for a lamp. He gives formulas and a diagram for the amount of nitrogen oxide formed as function of the speed with which the air is passed through the arc. His results show a great intrinsic difficulty of carrying out the process to best advantage. To produce as much nitrogen oxide as possible with a given amount of electrical energy, it is necessary to pass the air with a very high speed through the arc, but then we get a very low concentration of nitrogen oxide in the gas mixture and the wet treatment of the latter becomes more difficult. The author does not think that on account of this fundamental difficulty it will be possible to develop in this way a really cheap process for the fixation of atmospheric nitrogen. He offers another suggestion on the basis of the following considerations: The formation of nitrous oxide ($N_2 + O_2 + 2 \times 21,000 \text{ cal.} = 2NO$) requires theoretically 25 watthours per mol No. But the greater part of the energy of the arc is consumed for heating the unchanged portion of the gas mixture. Further, in the reaction with water ($2NO + 3O + aq = 2HNO_3 aq + 73,000 \text{ cal.}$) there are set free 36,500 cal. per mol NO, and this energy can hardly be recuperated for useful work. The suggestion which Mr. Rasch makes is to pass the air through a high-tension alternating-current arc playing in water, so that nitric acid is directly produced. Two arrangements for this purpose are described and illustrated. Other experiments were made with 220-volt direct current in different electrolytes. It was possible to form an arc in the liquid, the nitrogen of the air, blown through the liquid, being oxidized to nitric acid or nitrates without formation of gaseous nitrogen oxides. The experiments were only preliminary and could not be concluded, and the author suggests to others to continue them.

Is Oxidation of Nitrogen a Purely Thermal Effect or Not?—In order to investigate whether the fixation of atmospheric nitrogen by electric discharges through air is a purely thermal effect (like an electric furnace process), H. Lee and A. Beyer have made a long series of experiments, which are described in *Zeit. f. Elektrochemie*, Nov. 1, 1907. They compared essentially direct-current and alternating-current flames of equal energy consumption and used iron electrodes, platinum electrodes and Nernst filaments. The chief result is that the conditions under which the discharges occur which heat the air are of far greater importance than the question whether direct current or alternating current is used. But it is shown that the variable influence of the special conditions of discharge depends on the degree to which the supplied energy is consumed in the arc itself, so that the experiments are another proof of the theory that the oxidation of atmospheric nitrogen by electric discharges is purely a thermal effect.

Directly the opposite result is arrived at in a very interesting paper by F. Haber and A. Koenig, in *Zeit. f. Elektrochemie*, Nov. 15. For a time the hypothesis has been generally

accepted as correct, that the only effect of the electric arc is to heat the gas mixture to a high temperature, at which the thermochemical equilibrium requires the formation of a certain amount of nitrogen oxide, so that, according to this view, the electrical energy is first changed into heat. Haber and Koenig, of course, do not deny that such an indirect effect—change of electrical energy into heat with subsequent oxidation of nitrogen—exists, but they point out and make it very probable that there is also a direct oxidation of nitrogen by the electric discharge, i. e., a direct change of electrical into chemical energy. Berthelot's original statement that the silent discharge through air does not oxidize the nitrogen, has been proven to be wrong by Warburg and recently by Berthelot himself. If there is a direct change of electrical energy into chemical energy, this would be of very great importance for the industrial fixation of atmospheric nitrogen, since the essential requirement would no longer be to heat the air first to an extreme temperature and then to cool it suddenly. The higher the percentage of nitric oxide produced in the gas mixture the less satisfactory becomes the pure thermal hypothesis, because it leads to the assumption of very high mean temperatures in the arc and of exceedingly quick rates of cooling the gas mixture. As will be seen below, Haber and Koenig have succeeded in getting a gas mixture of more than 12 per cent NO; this would require, on the basis of the purely thermal hypothesis, a temperature of 4,600° C., and an enormous speed of cooling the gas from this temperature. But in Haber's and Koenig's experiments the gas mixture was passed at a slow speed through a stationary flame within a tube cooled from the outside with water. They used a pressure less than atmospheric pressure, in order to increase the free wave-length of the ions and the kinetic energy which the ions can accumulate in moving through the electric field. At the same time the flame column is broadened. Air or other mixtures of nitrogen and oxygen were sucked by means of a pump through a series of apparatus, among them the arc tube. The arc was produced by alternating current of a frequency of 50 periods, the 120-volt supply voltage being raised by a 4-kw. transformer to 5,000 or 10,000; the tubes in which the arc played were cooled from the outside with water. The chief results, obtained at a pressure of 100 millimeters, are given in the following table:

Original Composition of Gas Mixture.		NO Produced in
O_2	N_2	Per Cents by
Per Cent.	Per Cent.	Volume.
20.9	79.1	9.8
48.9	51.1	14.4
44.4	55.6	14.3
75.0	25.0	12.77
81.7	18.3	12.1

On the basis of the purely thermal hypothesis it would be necessary to assume temperatures between 4,300° and 5,000° in the apparatus, which is a very improbable assumption. For various reasons it is probable that the mean temperature in the arc tube was below 3,000°. Haber finally concludes that the best results should be expected from the use of cold arcs.

Flaming Ring.—In our Vol. V., p. 492, we noticed already how Brion has modified the flaming-disc method of Birkeland and Eyde into a flaming-ring method with good success. A very full illustrated account of his laboratory research with the flaming ring may be found in *Zeit. f. Elektrochemie*, Nov. 29.

Industrial Electrochemistry.

Direct Current or Alternating Current for Carbide Furnaces.—This subject is discussed by H. Lee and A. Beyer in *Zeit. f. Elektrochemie*, Nov. 1. If an electric arc is operated in air between metallic electrodes, a much higher voltage is required with alternating current than with direct current, because with alternating current the arc is broken periodically and must be lighted again. It is essentially different in electric furnaces, like carbide furnaces, because the arc plays here in a highly heated gaseous atmosphere. Experiments of the authors show that with the same arc length the voltage is here the same for direct and for alternating current. The results in carbide manufacture are the same with direct or alternating current, under otherwise equal conditions. In laboratory furnaces direct current at 30 or 35 volts is advantageous. On an industrial scale alternating current is preferable, on account of its easier transmission and transformation, and the higher voltage (60 or 65 volts) is necessary, because in order to pass a large current one must have a voluminous arc of a certain fair length.

Industrial Electrolytic Electrolysis.—B. Neumann gives in *Zeit. f. Elektrochemie*, Jan. 17, a review of developments during the second half of last year. New electrolytic methods of the electrometallurgy of copper, bismuth, lead, nickel, tin, zinc, silver and gold are briefly described and critically discussed, mostly on the basis of patent specifications. Some notes on industrial developments are interesting. Thus it is stated that the Betts process for lead refining, after having been introduced into England, is now also to be used in a plant in Germany. A new method of making seamless copper tubes by electrolysis has been devised. While Elmore polishes the rotating copper cylinder by means of an agate, a German patent (175,470) proposes to polish the deposit and remove any gas bubbles by means of a powder of kieselgur (using 20 kg. per 180 liters). S. Cowper-Coles (English patent 13,972) proposes a method of rotation, using 1,500 to 2,000 r. p. m.

Edison Accumulator.—In *Zeit. f. Elektrochemie*, Nov. 22, J. Zedner makes some polemical remarks on Foerster's former paper (see our Vol. V., p. 465) concerning some special points of the nickel electrode, especially concerning the question whether in the first period of discharge of the nickel electrode Ni_2O_3 is the only active oxide. This has been claimed by Zedner, while Foerster has shown before and shows again in his reply in *Zeit. f. Elektrochemie*, Jan. 10, that the facts require the assumption of the existence of an oxide higher than Ni_2O_3 together with the latter in the nickel electrode during the first step of the discharge; he therefore maintains that between Ni_2O_3 we have NiO_2 , probably in form of a solid solution of the latter in the former.

Theoretical and Experimental Electrochemistry.

Automatic Current Regulator.—In *Zeit. f. Elektrochemie*, Oct. 11, O. Sackur describes an automatic regulator for obtaining constant current with varying voltage. It is shown in Fig. 1. In the cell A water is decomposed between two large nickel electrodes, and the oxygen and hydrogen gas mixture escapes through the capillary tube B. Inside the cell A a pressure is produced which is proportional to the speed with which the gas escapes from B, and, therefore, also proportional to the current. The terminals *a* and *b* of cell A are connected with the terminals *a*₁ and *b*₁. In the sketch, S is the source of current, X is the apparatus in which the current is to be kept constant, G an ammeter, and W_1 , W_2 , W_3 adjustable rheostats. By regulating W_1 the current through G and X is first adjusted to the desired value. Then the tube F is raised or lowered until the mercury is just below the platinum point C, but does not actually make contact with it. Further, the screw E is so adjusted that it is just above the mercury surface without actually making contact. If now

the voltage of S should fall and the current in X and in the cell A will decrease, the gas pressure in A will decrease and the mercury in the manometer tube will rise and will make contact with C, so that the branch circuit W_2 C D in parallel with W_3 is closed. The current through A G X will therefore increase, contact C is broken, etc. On the other hand, if the e. m. f. of S should rise, the mercury will make contact with the screw E, and the branch circuit D E W_3 is closed, so that the current in A G X decreases. Then the contact E is broken, etc. Some precautions are described which are necessary if the apparatus is to be used for a considerable length of time.

Rheostat for Laboratory Purposes.—In *Zeit. f. Elektrochemie*, Nov. 22, C. Fredenhagen describes a portable rheostat for laboratory purposes. It consists of twenty-one resistors connected in series and having an aggregate resistance of 85.25 ohms. These twenty-one resistors are divided into five groups, and in each group the resistance of one resistor equals

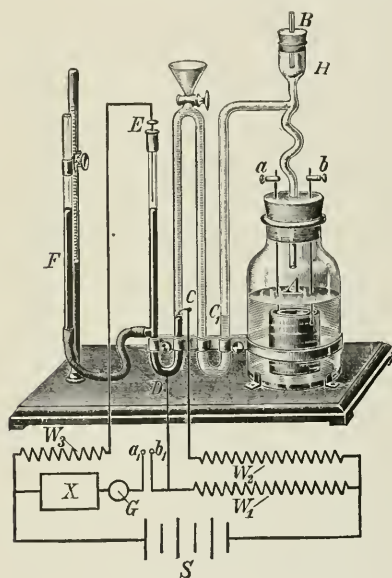


FIG. 1.—AUTOMATIC CURRENT REGULATOR.

the sum of the resistances of all resistors in the next group, as follows

Four resistances, each 16.00 ohms, = 64.00 ohms.	
" " " 4.00 " = 16.00 "	
" " " 1.00 " = 4.00 "	
" " " 0.25 " = 1.00 "	
" " " 0.05 " = 0.25 "	
85.25 "	

The last resistor in each of the first three groups is subdivided into four parts, the last resistance in each of the last two groups into five parts, which can be short circuited at will by special contact levers, one for each group. A main contact lever controls the whole system. This arrangement enables one to adjust the resistance in steps of 0.01 ohm between the limits of 85.25 ohms and 0.01 ohm. It is claimed that a rheostat of the same total resistance, but based on the decimal system, would require 70 per cent more single resistors.

Passivity of Iron.—In *Zeit. f. Elektrochemie*, Oct. 4, 1907, W. J. Müller and J. Königsberger describe experiments on the anodic and cathodic behavior of iron mirrors. They have found that active iron and passive iron have the same coefficient of reflection, and from this result they conclude that the passive state of iron cannot be due to an oxide film.

Passive State.—A. Loeb and M. Le Blanc, in former experiments on electrolysis with alternating currents, had found that Cu-electrodes, which had been annealed and quenched in alcohol, as well as Cu-electrodes which had been rubbed with emery paper, gave very much lower efficiencies than crystalline electrodes. Similar effects were observed with zinc and nickel. The "passive" state of these electrodes cannot be explained by an oxide film. In *Zeit. f. Elektrochemie* of Dec. 6, A. Loeb argues that there are reasons to assume that we have here to do with an "over-voltage" phenomenon which retards hydrogen evolution.

The Nature of Over-Voltage.—In *Zeit. f. Elektrochemie*, Oct. 18, E. Müller endeavors to show that Kauffler's attempted explanation of the nature of over-voltage (see our Vol. V., p. 467) is wrong. He maintains that the hypothesis of a very high hydrogen or oxygen pressure at electrodes, showing the phenomenon of over-voltage, is not superfluous, but on the contrary very useful.

Viscosity and Conductivity.—It has formerly been found that in many cases the conductivity of a solution is approximately inversely proportional to its viscosity. Fousseran has studied the behavior of fused electrolytes, and has found that in many cases the product of viscosity and conductivity is approximately constant. K. Arndt discusses this rule on the basis of experiments with fused mixtures of NaPO_3 and B_2O_3 . His chief result is that in such ranges of temperature in which the salt is only soft, the above rule does not hold good, but that it represents a useful rule at higher temperatures when the salt is really fluid. In this connection he has derived the conclusion that fused electrolytes are completely dissociated into ions.

Analysis.—In *Zeit. f. Elektrochemie*, Jan. 3, a review is given by F. Foerster of the well-known recent advances made in electro-analysis with strongly circulated electrolytes. He acknowledges the great advantages and ease of E. F. Smith's methods of rapidly determining anions, and especially halogens, and alkali and earth-alkali earth metals. With this exception, however, he does not think that the field of applications of rapid methods with stirred electrolyte is wider than that of the methods using a stationary electrolyte, so that the sole advantage of the circulated electrolyte is the reduction in the duration of analysis. For certain industrial purposes this reduction in time is of great importance. But Foerster thinks that in other cases slow methods may do just as well, especially since they do not require special apparatus. He urges to pay in future more special attention to the development of slower methods with non-circulated electrolyte. He seems to lope much from the use of platinum-screen electrodes. With reference to this review, two brief papers are published by A. Classen and A. Fischer, with respect to some special points. A. Classen states that analysis with circulated electrolyte has been studied in his laboratory independently of American investigators. (In parenthesis it may be noticed that he mentions three names of Americans, but not E. F. Smith, who is evidently included in the abbreviation "u. a." "and others.") A. Fischer emphasizes the great advantage of rapid methods. In *Zeit. f. Elektrochemie*, Nov. 22, 1907, W. Neumann suggests an electrochemical method for qualitative detection of very small quantities of zinc. It is based on the deposition of zinc or a copper cathode from alkaline zincate solutions, and enables one to detect very small traces of zinc.

Valency.—In a theoretical note on the nature of valency in *Zeit. f. Elektrochemie*, Oct. 4, W. Peters makes the following suggestion: Within any molecule there are two counteracting forces; first, chemical affinity, which holds the atoms together on account of the attraction between the electric charges of the atoms, and, second, the oscillations of the atoms due to heat. At the absolute zero point of the temperature only the affinity acts. With rising temperature the atoms in a molecule begins to oscillate, and not only the amplitude of oscillations but the distance between the atoms increases with increasing temperature. "Valency is that part of the affinity of an atom which can manifest itself with respect to other atoms under the existing conditions of pressure and temperature." "If two ideal gases have equal numbers of atoms, equal molecular heats and equal Poisson coefficients at the same temperatures, then the sums of the valence numbers of their atoms are equal."

Valence of Hydrofluoric Acid.—G. Pellini and L. Pegoraro discuss in *Zeit. f. Elektrochemie*, Sept. 13, 1907, the question whether the molecular formula is HF or H_2F_2 , and decide in favor of the former formula.

Electrolytic Reduction.—In *Zeit. f. Elektrochemie*, Oct. 25, 1907, H. Leiser describes a modification of the Oettel apparatus for direct reading the percentage figures in electrolytic reductions. The same issue contains a paper by the same author on the electrolytic reduction of tungstic acid.

Organic Chemistry.—In *Zeit. f. Elektrochemie*, Sept. 20 and 27, 1907, a review is given of recent progress in the electrolysis of organic compounds, electrolytic reductions and oxidations and other applications of the electric current in the field of organic chemistry.

Speed of Neutralization.—In *Zeit. f. Elektrochemie*, Jan. 3, R. Abegg and J. Neustadt give a brief preliminary account of an attempt to measure the velocity of neutralization at low temperatures. Solutions of HCl and LiOH in ethyl alcohol were mixed, and the electric conductivity measured at temperatures of -80° and -100° C. The results of one experiment seem to indicate that, at the end of mixing, the neutralization was not got complete, but the results are not conclusive.

Radio-Activity.—In *Zeit. f. Elektrochemie*, Nov. 8, O. Hahn gives a good summary of the various investigations which have been published between May and October, 1907, on the radiation from radio-active substances and on radio-active substances themselves, also on Ramsay's observations on the transmutation of elements.

Atomic Weight of Chlorine.—The *Bulletin of the Bureau of Standards*, Vol. IV., No. 3, January, 1908, contains an account of W. A. Noyes and H. C. P. Weber's investigation of the atomic weight of chlorine. The value as found for the atomic weight of chlorine is 35.184, with a probable error of ± 0.0013 , while the value obtained for the molecular weight of hydrochloric acid is 36.184, with a probable error of ± 0.0012 . The combined average for the atomic weight of chlorine is 35.184, with a probable error of ± 0.0008 , on the basis of hydrogen = 1. On the oxygen basis this value becomes 35.452 if $\text{H} = 1.00762$ (Morley) and 35.461 if $\text{H} = 1.00787$ (Noyes). The values for silver calculated from Richards' ratio and these two values are, respectively, 107.865 and 107.893. The mean values must be considered as most probable at the present time. These are 35.457 for chlorine and 107.88 for silver. In the same issue A. C. P. Weber describes a method of preparation of chloroplatinic acid by electrolysis of platinum black.

Steel.

Electric Steel Furnace.—The *Rivista del Servizio Minerario* gives an account of the results obtained with the Stassano electric steel furnace at Turin, which are summed up in the *London Electrician* of Jan. 24 as follows: In the works there

are in operation one revolving 200-hp. furnace, another of 1,000 hp. on the same system, and three stationary furnaces, two 100 hp. and the other 1,000 hp. The stationary furnaces, though lower in cost by a third, are only suitable for simple fusing operations, such as are usual in the ordinary Martin furnace. The revolving furnaces cost, respectively, \$4,000 and \$10,000, and are capable of producing 2.5 to 3 tons and 16 to 18 tons per 24 hours. The stationary 100-hp. furnace costs about \$700, and produces about 1 ton every 24 hours. For working these furnaces three-phase currents at 21,500 volts are taken from the public mains, and are transformed down to 80 volts for the 100-hp. furnace, 100 volts for the 200-hp. furnace, and from 100 to 150 volts for the 1,000-hp. furnace. The 100-hp. furnace works on the single-phase system, and takes current up to 1,000 amps. The 200-hp. furnace is three-phase, while the 1,000-hp. has six electrodes and takes 1,800 amps on each phase.

Calcium Carbide and Acetylene.

A New English Carbide Plant.—In *London Electrical Engineering* of Nov. 28, we find some notes on a new plant for the manufacture of calcium carbide which is being erected at Thornhill, Yorkshire. The factory is being built for the Imperial Automatic Light Co., Ltd., and it is hoped that work will commence early in 1908. The works as at present designed are capable of an output of from 2,200 to 2,500 tons of calcium carbide per year, and, as already announced, the necessary electric power will be obtained from the Yorkshire Electric Power Co. The Imperial Automatic Light Co. claim that they can maintain a 2,500-candle-power acetylene flame for 1 hour at a cost of 9 cents. Their apparatus is said to be not only portable and clean, but absolutely safe in its automatic working. The cost of the plant for the 2,500 candle-power is given as \$60, and a larger plant, with five jets, each giving 2,500 candle-power, costs about \$92.00. The plant may also be used for welding by means of the oxy-acetylene flame. With respect to the safety of a good automatic acetylene lighting plant the writer of the note makes the following remarks: "At Strathyre, in the Highlands of Scotland, the writer has seen a plant in the Temperance Hotel of this small village. The plant is manipulated entirely by the proprietor, who is absolutely blind. He is able by feeling to manipulate the whole apparatus and describe its working. No accident has ever happened, and absolutely no smell can be noticed when the hotel is lighted up. One has only to notice how badly the bulk of our railway stations are lighted to wish that the railway companies would employ acetylene as a source of illumination in those stations where electric current is not conveniently available; it would probably cost very little more than the present gas and oil lamps, and in some cases it would be actually cheaper by a considerable amount."

Explosions in Chemical Works.

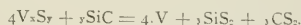
Static Electricity.—In an article of the *Chemiker Zeitung* of Dec. 18, M. M. Richter discusses the production of static electric charges by the friction due to belt driving. Such static charges are produced especially if some resinous material is applied to the belt to cause adhesion. By means of electrostatic measurements, belt-potential difference of 13,000 volts were detected, the fly-wheel being negatively charged and the leather belt being positively charged. The effect is influenced largely by humidity in the air and on the belt. In chemical works, where the atmosphere contains vapors of oils and chemicals, dangerous explosions may be produced by sparks, due to such electrostatic charges. These electrostatic charges may be avoided if the belt is smeared with acid-free glycerine, since its hygroscopic nature keeps the belt moist and prevents the formation of static charges. This mixture, which may be applied by means of a sponge while the belt passes around, should be renewed weekly.

ANALYSIS OF CURRENT ELECTRO-CHEMICAL PATENTS.

Electric Furnaces.

Vanadium.—F. M. Becket, 876,313, Jan. 14, 1908. Application filed July 29, 1907.

Vanadium is reduced from its sulphide directly by means of silicon and carbon, preferably in form of carborundum. The materials are mixed and heated in an electric furnace. The chief reaction which presumably occurs in the reduction of vanadium sulphide may be expressed by the following general equation:



By using a closed furnace and maintaining non-oxidizing conditions both the silicon and carbon disulphides may be collected, or they may be burned with air, to recover the sulphur contents as sulphur dioxide. For the production of an alloy of vanadium the metal to be alloyed with vanadium is added to the charge either as metal or as sulphide. The direct product is claimed to be very low in carbon and to contain merely traces as sulphur.

Molten Peroxides.—Hans Foersterling and Hector R. Carveth, 879,452, Feb. 18, 1908. Application filed March 6, 1907. Assigned to Roessler & Hasslacher Chemical Co.

Fused sodium peroxide is made in the apparatus shown in Fig. 1; *a* is a water-jacketed vessel tightly closed on the top by the cover *d*. By means of the electrodes *e* it is possible to heat the contents of the vessel, and that is the only purpose of the electric current. The tank *g* contains molten sodium, while through the pipe *j* air is delivered under pressure into

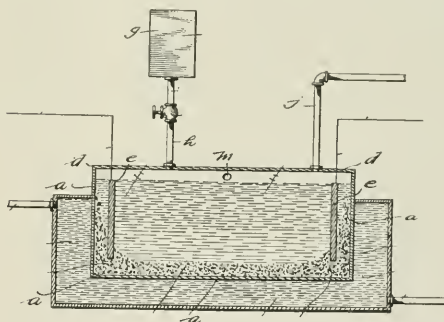


FIG. 1.—MANUFACTURE OF PEROXIDES.

the vessel. The vessel is first filled with fused sodium peroxide, and by means of cooling the walls with water a solidified peroxide lining is produced. By means of the electric current the peroxide held within the lining is kept in the fused state. Molten sodium is then permitted to flow through pipe *h* into the vessel *a*, while simultaneously air is admitted through pipe *j*. The molten sodium floating on top of the molten sodium peroxide is rapidly oxidized by the air and taken up by the molten peroxide, the excess of molten peroxide flowing out continuously through the outlet *m*. The heat generated by the oxidation of the sodium is, in the progress of the operation, practically alone sufficient to keep the sodium peroxide molten, so that little or no electric energy needs to be supplied to the cell afterwards.

Electrolytic Processes.

Electrodeposition of Copper.—Sherard O. Cowper-Coles, 873,508, Dec. 10, 1907. Application filed Nov. 12, 1906.

In electrodepositing copper from solutions which have to be maintained in an oxidized state (for instance, from a

cupric solution), the solution is brought continuously into intimate contact with air. For this purpose the electrolyte is conveyed through an atomizer consisting of revolving wheels or vanes, which throw the solution off them in the form of a fine spray against an outer casing. By subjecting the solution to strong light, such as daylight or arc light, it is claimed the effect of clarifying the solution is obtained.

Water Filter.—N. A. Brannon, 866,618, Sept. 24, 1907. Application filed April 11, 1906.

An electric water filter for household use in which the water passes through a filter and is at the same time subjected to the electric current produced by a short-circuited couple, the intention being to kill in this way the bacteria. The couple comprises zinc fragments and copper turnings. A porous filter partition of insulating material separates the two elements, which, however, are connected together by an electric conductor.

Batteries.

Storage Battery.—T. A. Edison, 879,612, Feb. 18, 1908. Application filed June 29, 1904. Assigned to Edison Storage Battery Co.

In the operation of the Edison alkaline battery excessive foaming has often taken place, which may, perhaps, have been due to the presence of microscopic scales in albuminous or gelatinous organic matter in the solution. This difficulty has been overcome by carefully filtering the alkaline solution through bone-black which has been first purified by washing in a hot caustic potash solution and then washing with water.

Storage Battery.—T. A. Edison, 876,445, Jan. 14, 1908. Application filed May 10, 1907.

In the development of the Edison alkaline storage battery the storage capacity of the nickel element has been found wanting. An effective remedy is to add about 2 per cent by weight of lithium hydroxide to the solution of alkaline hydrates. Preferable amounts of the latter are 15 per cent in the case of sodium hydrate and 21 per cent in the case of potassium hydrate. The addition of lithium hydroxide increases the capacity of the Edison battery by about 10 per cent, while the increase of the time over which the capacity may be maintained "is remarkable and of the highest commercial importance."

Primary Battery.—W. M. Brodie, 879,361, Feb. 18, 1908. Application filed Feb. 15, 1905. Assigned to Edison Manufacturing Co.

In order to increase the surface of the copper oxide plate in an Edison-Lalande cell the inventor produces corrugated copper-oxide plates without any binder by means of special dies. The dies are so formed that the tops or projecting portions of the corrugations of one die are opposite the depressions of the corrugations of the other die. Any abrupt curves are avoided and the corrugations are made well rounded. In this way it is possible to produce a deeply corrugated plate of sufficient strength.

Discharges Through Air.

Nitric Acid from Air.—H. Pauling, 877,447, Jan. 21, 1908. Application filed April 6, 1906. Assigned to Salpetersäure Ind. Ges.

After nitrogen oxide gases have been produced from air by means of electric discharges, water or steam is added to the hot gases so as to form an intimate mixture, while the nitrogenous gases have a minimum temperature of 200° C. The quantity of water or steam added is so proportioned that the vapors of nitric acid produced thereby have a temperature at which they are still in a gaseous condition; that is, a temperature of about 100° C. "The object in this case is to be able to pass the nitric acid while in its gaseous condition into metallic pipes, where it is cooled down to a certain tempera-

ture. It is then conducted into suitable clay apparatus for condensation. In these metallic cooling apparatus the gases of nitric acid are so far cooled down that the clay apparatus shall not be affected by an undue temperature of the gases received for condensation. Also the hot gases of reaction—that is, the nitrogenous gases resulting from the action of the electrical discharges on the air—may be received in metallic pipes, and here be mixed with the requisite quantity of water or aqueous vapor. It is advantageous, in connection with this process, to use such air as contains no more than ½ per cent of its volume as nitric oxide."

Nitric Acid from Air.—H. Pauling, 877,446, Jan. 21, 1908. Application filed Dec. 18, 1905. Assigned to Salpetersäure Ind. Ges.

After nitrogen oxides have been formed in air by means of electric discharges it is important to chill the gas mixture quickly. The inventor has formerly proposed the use of either tubes cooled by water or an atomizer. He now proposes to substitute plates, since they effect a more rapid cooling and also effectively avoid the formation of an aureola.

Nitric Acid from Air.—H. Pauling, 877,448, Jan. 21, 1908. Application filed June 30, 1906. Assigned to Salpetersäure Ind Ges.

To produce long arcs at high tension without danger of short circuits, the author proposes the arrangement shown in Fig. 2, where the upper diagram is a vertical section on the line 1-1 of the lower diagram, and the lower diagram is a horizontal section of the line 2-2 of the upper diagram. A current of air is blown through the pipe 1 between the electrodes 2, 2, which are arranged to diverge in lateral and upwards direction from pipe 1. The channel 4 receives another current of air, which enters in the direction of the arrow I. The current of air passing along the channel 4 acts in its turn on the portion of the electrodes 2, 2 projecting into the channel 4, so as to blow between them and convey, in connection with the current of gas leaving the pipe 1, the discharges along the electrodes, so as to form arcs of the desired lengths with the avoidance of short circuits. The velocity of the current of gas in the channel 4 is less than that of the current arriving in the channel 3. These velocities must be ascertained by experiment.

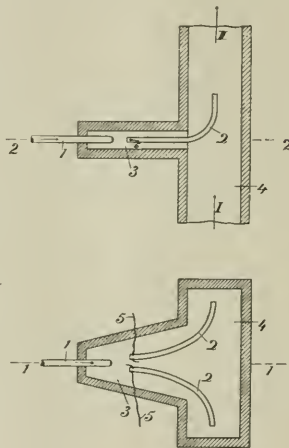


FIG. 2.—NITRIC ACID FROM AIR.

Cement Manufacture.—Seven powerful Corliss engines, designed for installation in a single industrial plant, with electric generator, motors, transformers and a full complement of auxiliary apparatus, including a separate condenser for each of the engines, constitute an order which is notable at any time and particularly so at present. This quantity of power machinery, now being built and installed by Allis-Chalmers Co. in cement mills at Nazareth, Pa., operated by the Atlantic Portland Cement Co., indicates something of the proportions which the cement-making industry is assuming. This industry appears to be indeed in a relatively healthy condition of trade, which contrasts strongly with the continued inactivity in some less favored industries.

Ferro-Vanadium for Foundry Purposes.

The use of vanadium for making special vanadium steels has attracted much attention during the last years. The chief properties of vanadium steel are as follows: The elastic limit is increased without an impairment of the ductility of the steel. That is, an exceedingly strong steel is obtained with its softness still remaining. Coupled with these most valuable properties is another, and that is the extreme resistance to deterioration when the metal is subjected to severe and continued strains in service. It is non-fatiguing, and therefore an ideal railroad and rolling-mill metal.

On the other hand, the use of vanadium for iron foundry purposes has received less attention. Dr. RICHARD MOLDENKE, the well-known secretary of the American Foundrymen's Association, has recently carried out some very interesting pioneer work in this field. He points out that the use of vanadium suggests itself for various purposes in the iron foundry. The very first casting which might be benefited is the car wheel. Next, the various kinds of rolls; then alkali pots, pump parts, etc.; anywhere, where strains are heavy and oft repeated, either direct tension and compression alternately, shock, or great variations in temperature.

In order to get some more definite idea of the effects of vanadium on cast iron, tests have been carried out at Dr. Moldenke's Castle in Watchung, N. J., using melted scrapped car wheels for white iron, and a good machinery pig iron for a variety of gray iron. A ferro-vanadium carrying high carbon was selected because it melted at a lower temperature and would also be cheaper for the foundryman. Varying proportions were added to the ladle full of molten metal, first in lump form; and as this did not give satisfaction with the small quantities of iron used at a time, the alloy was powdered before using.

Inasmuch as vanadium, besides being a great strengthener, is also a powerful deoxidizing agent, and the increase in strength obtained by its use might be attributed to the purification of the iron only, a further series of tests was included, in which the ladle was first treated with 80 per cent ferro-manganese in sufficient quantity to add 0.5 of manganese and then the ferro-vanadium. In order to obtain some light on the deoxidizing power of vanadium, a set of tests was also made with burnt metal.

The test bars were of the regulation kind, as prescribed by the American Society for Testing Materials, namely, 1¼-inch round, cast on end and in dried molds. The cupola was a small one, specially made for the tests, 22 inches inside the lining. The tuyeres were pretty close to the bottom, as but little iron was to be held at a time. A Sturtevant fan supplied the air, power being obtained from a small gasoline engine.

The test bars, dumped when cold, were only brushed and then broken transversely on a 5,000-pound Richle testing machine. The test bars were carefully calipered, results of tests tabulated and the modulus of rupture calculated out in pounds per square inch.

Some tests were made with burned gray iron (burned grate bars, stove iron, etc.). The modulus of rupture of this iron was 25,500 per square inch. By adding 0.05 per cent vanadium this was raised to 43,380.

Some tests were then made with burned white iron. Without vanadium the modulus of rupture was 28,170 pounds per square inch. By adding 0.50 manganese and 0.05 vanadium, this was raised to 37,400.

An extended series of tests was made with machinery gray iron (melted pig iron, no scrap). Without vanadium the modulus of rupture was 38,680 pounds per square inch. By gradually adding small percentages of vanadium this could be raised to 53,750.

Even more remarkable results were obtained with remolded car wheels, white (no pig iron). Without vanadium the modulus of rupture was about 28,000 pounds per square inch.

By gradual additions of vanadium and manganese this could be raised to 77,000. Some of the results of these tests are summed up in the following table, giving the chemical composition of the test pieces and the modulus of rupture in pounds per square inch:

Si.	S.	P.	Mn.	V.	Lbs. Per Sq. In.
.60	.122	.399	.38	none	27,760
.45	.096	.423	.40	.36	50,070
.66	.110	.591	1.15	.25	58,270
.45	.119	.414	.50	.31	56,130
.53	.084	.431	.74	.27	57,990
.42	.112	.417	.40	.45	59,316
.50	.081	.374	.54	.22	77,050

The ferro-vanadium used in these experiments contained 14.67 per cent carbon and 0.18 silicon. While the vanadium content is comparatively low, this is a very good alloy for foundry purposes, as cast iron is already high in carbon and the silicon is too small to cut any appreciable figure in the results.

Dr. Moldenke's conclusion is as follows: "The results are sufficient to strongly recommend the new alloy to the consideration of foundrymen. If but a part of the resistance to deterioration found by adding vanadium to steel should be proven by service trials to exist in cast iron, then, on the score of safety to human life alone, the metal belongs in every car wheel. A still better method would be to use a more powerful deoxidizer than manganese, and add the vanadium on top of it."

The investigations of vanadium in cast iron are intended to be continued, making provision to keep the ladle with melted iron heated up for a fairly long period, so that better mixing of the alloy may result, and hence more accurate results can be obtained. The full account of Dr. Moldenke's tests with all the figures may be found in the *Transactions* of the American Foundrymen's Association. This paper has now been reprinted as a pamphlet of the Vanadium Alloys Co., of New York City, who will be glad to send it to those interested. The Vanadium Alloys Co. are makers of the ferro-vanadium used in Dr. Moldenke's interesting experiments.

Metallurgical Activity at Guanajuato.

Probably no part of Mexico has been given more widespread publicity throughout the United States, within the past few years, than the Guanajuato mining district. The circumstance which has, in a relatively brief period, transformed this camp from a state of inactivity to that of the most active is the fact that through the advent of American capital and enterprise an hydro-electric plant, which transmits power over a distance of 120 miles from the nearest available water power, has been placed in operation here. The turbine installed has a capacity of 5,000 hp., and is a single horizontal unit of the Allis-Chalmers scroll case type, operated by the Guanajuato Power & Electric Co., at Guanajuato.

There were millions of tons of ore in the dumps of the old mines, and underground vast reserves practically developed or used as filling. The dumps were sampled, extensive cyanide tests made, and with cheap power available, these properties have become very valuable.

One of the representative mills of the district is that owned by the Porogrina Mining & Milling Co. In this mill practically the entire equipment was furnished by Allis-Chalmers Co., of Milwaukee. The ore goes to Gates style "K" gyratory breakers, and discharges onto a belt conveyor for distribution to the bins back of the stamp batteries. The present plant, with 120 stamps, handles about 9,000 tons monthly, which amount it is expected will shortly be increased to 11,000 tons, following certain proposed changes in the treatment of ores. Ore was originally crushed to 40-mesh in batteries not set in cyanide

solution. The product of each five stamps went to a Wilfley table for concentration, while the tailings passed to two 6-foot cones, used as pulp thickeners. From the thickeners the sands were conveyed to Gates tube mills, 5 feet x 20 feet, each driven by a 75 hp. induction motor. Iron plates are used here for tube mill linings in place of silex.

The sands from the cone separators were run to one of two sand collecting tanks, with Butters distributors and center discharge gates, arranged with curtains to take off slimy water, which was returned to the cones. From the collectors the sands went into a sand leaching excavator. The overflow from the cone plant passed to two 36 feet x 12 feet steel tanks, arranged with overflow launders used as slime collectors. The underflow, which is a thick slime, was delivered to a slime agitation plant, using combined mechanical stirring and air agitation.

It is now proposed to increase the output by the following changes in treatment: To crush in solution and take out plates; to put classifiers ahead of concentration, and to crush only to 30-mesh, thus increasing tonnage. It is estimated that the pulp when it reaches the cyanide plant will have 35 per cent to 40 per cent of the values in solution, which will be decanted and precipitated and enable the cyanide plant to handle a larger quantity than has been practicable heretofore.

The New 6000-Ton Garfield Concentrator of the Utah Copper Co.

At the present time there stands blocked out in the mines belonging to the Utah Copper Co. more than 100,000,000 tons of ore, the milling of which will probably be done at the new Garfield concentrator plant just brought to completion. This is estimated to have cost \$3,000,000, including a \$750,000 power plant.

The concentrator buildings are located 16 miles east from Salt Lake City, on a slope facing the lake. The plant is fed by means of the Bingham branch of the Rio Grande Western Railroad from the company's mines in Bingham Canon. It is designed to treat 6,000 tons of porphyry daily, with a copper content varying from 1.5 to 2.5. The resulting concentrates carry more than 150,000 pounds of copper.

Ore is received in a bin building with a holding capacity of 36,000 tons, or six days' supply. The concentrator proper is divided into twelve separate groups, each a complete unit in itself and having a capacity of 500 tons, the machinery of which is driven by means of induction motors.

COARSE CRUSHING DEPARTMENT.

Ore is taken from the bins in collecting cars, then discharged through centrally-placed bottom-gates directly onto the grizzlies over the hoppers of four 7½ type-"K" Gates gyratory breakers, built by the Allis-Chalmers Co., Milwaukee, each having a capacity of 100 tons per hour. These crushers are fed from the hoppers through discharge pockets with vertical gates operated by compressed air. Only the oversize from the grizzlies goes to the crushers; the undersize passes along to the first set of trommels, of which there are two for each of the Gates crushers.

Elevated to the mill top, the dry, coarse crushed ore is screened wet through No. 10-mesh screen. Pulp passing the screen is classified and then sent to the jigs. The concentrator floors are occupied by 72 jigs, 1,104 6-foot vanners and 48 concentrating tables. Each of the twelve mill sections may be operated entirely independently from the others.

The power for operating the coarse crushing machinery is supplied from four 150-hp., 3-phase induction motors, 440 volts. Each motor is belted to a line shaft, which drives a gyratory crusher, a set of roughing rolls, two trommels and elevators.

POWER PLANT EQUIPMENT.

A power station having nearly 7,000-hp. capacity is required for the operation of the main mill and a small 700-ton mill at Bingham Canon, originally built as an experimental plant. The power house, built of reinforced concrete brick and steel, 158 feet x 228 feet, stands a short distance below the mill. Twenty water-tube boilers of the Heine type, built by the Risdon Iron Works, of San Francisco, furnish a boiler capacity of 600 hp. each for reciprocating engines, direct connected to 3-phase alternating-current generators. Two of the engines installed were built by Allis-Chalmers Co., Milwaukee. They are horizontal cross-compound Reynolds-Corliss units, of the heavy duty type, with cylinders 54-inch x 48-inch stroke, and designed to develop normally 1,500 hp. each at 100 r. p. m.

Messrs. J. G. White & Co. acted as consulting engineers for the plant. Power is generated at 4,000 volts, which is stepped down to 440 volts for use in the mill. Power for Bingham Canon mines and mill is transmitted over a 15-mile line at 40,000 volts.

The Ammonia-Cyanide Process for Treating Copper Ores with Recovery of Precious Metals.

The Mosher-Ludlow ammonia-cyanide process, which is now being introduced into practice by the Ammonia Cyanide Engineering Co., 347 Monadnock Block, San Francisco, is an interesting new development in the leaching and treatment of ores carrying copper with or without gold or silver values. In mechanical equipment as well as general arrangement of plant the process is similar to the cyanide and chlorination leaching processes, in so far as the solution of the metal values is concerned. But it differs radically from the latter two processes in the precipitation of the metallic values from the solution, since the essential feature of the new process is the recovery of the metal from the ammonia solution through boiling the latter in the Mosher-Ludlow continuous boiling-out apparatus, to which we referred already in our June issue, 1907 (Vol. V., p. 242).

The use of ammonia and potassium cyanide for the extraction of copper, gold and silver from ore is not a new idea. The fundamental patent is probably that of Simpson (United States patent 323,222, issued July 28, 1885), who first suggested the use of ammonia and potassium cyanide for such purposes.

The distinguished German metallurgist Dr. Schnabel and associates, already, thirty years ago (1878), installed ammonia leaching plants for the extraction of zinc oxide from zinc-lead dross, waste from desulphurizing works, with subsequent boiling-out of the zinc as oxide. Such plants at Lautenthal and at Hoboken, near Antwerp, are believed to have been operating with brilliant success for a number of years. For detailed description of this process the reader may be referred to Schnabel's *Metallurgy*, Vol. I., second (English) edition, pp. 679 to 687.

To use Schnabel's own words, "the process depends upon the easy solubility of zinc oxide in ammonium carbonate solution, and upon the fact that from this solution ammonia and a part of the carbon dioxide may be recovered by boiling, while zinc carbonate is precipitated and may be converted into the oxide by ignition. The solvent power of the ammoniacal solution is restored to it by passing into it the carbon dioxide given off upon heating the basic zinc carbonate." Schnabel's own criticism of the process is that it is "complicated, requiring costly plant and expert attendance, and that the zinc is obtained in a form in which it sells for less than metallic zinc, though there is the advantage that the silver yield is high."

From Schnabel's own description of the details of the process it is quite certain that the weak point was mainly in the ammonia distilling plant. His way of boiling off the ammonia and precipitating the zinc carbonate would probably never do

in the treatment of ores under large-scale milling conditions, where immense tonnages are to be handled, and where the apparatus must not be too expensive or cumbersome either in first cost or subsequent operation. It would seem that just at this point the Mosher-Ludlow process, with continuous operation as fundamental principle, as described below, is specially strong.

With respect to the use of ammonia, an immense number of patents have been taken out in the past few years in this country and abroad, but very little has been done from a practical standpoint to the present time in the use of ammonia for treating ores. It is, therefore, of special interest to know that the Mosher-Ludlow process is to be used on a 30-ton ammonia

Where the percentage of copper is large the aim is to first extract as much of the copper as is possible by plain ammonia, and to leave the gold and silver values to be subsequently extracted with a weaker ammonia solution containing fractional percentages of potassium cyanide. But instead of working in this way it may be preferable in many instances to add the cyanide at once to the ammonia and to simultaneously extract all of the values, including copper, gold and silver, with an ammoniacal solution containing one to several pounds cyanide per ton. The object aimed at is to reduce the consumption of cyanide to a minimum in the presence of copper, by substituting ammonia as the solvent for the copper, thereby permitting the minute amounts of potassium cyanide added to the ammonia solution to simultaneously extract the gold and silver values.

To recover the metallic values from the ammonia-cyanide-copper-gold-and-silver-bearing solution, it is passed through the continuous boiling-out still, to precipitate the copper as CuO . The boiled-out solution holding the gold and silver values is agitated with the least amount of zinc dust, or passed through zinc boxes to recover such gold and silver as the boiled-out solution may contain.

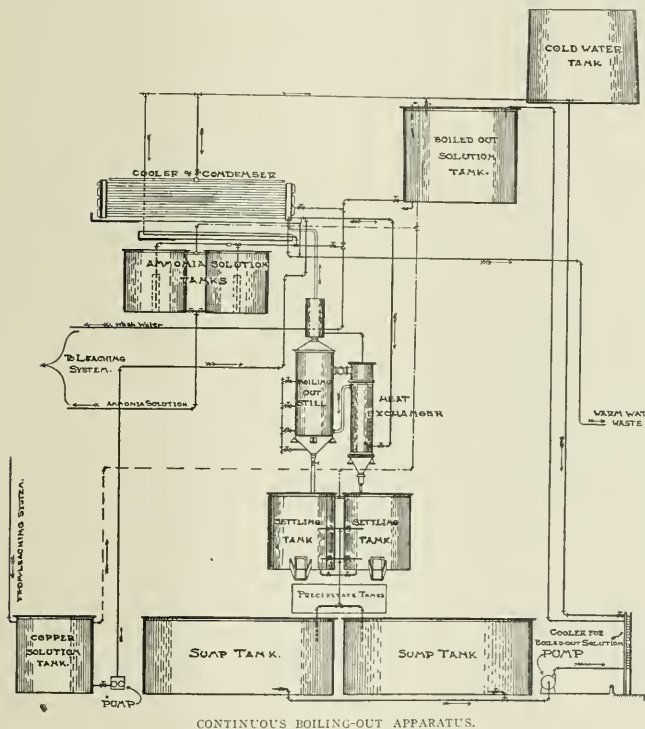
Before we pass over to the description of the boiling-out apparatus a few remarks may be made concerning the nature of the ores which can be treated by this process. It is claimed that the complex mineral character of an ore is of no importance to the success of the process, since the ammonia will readily extract the ammonia-soluble metals from gangue with a composition of minerals, which would render acid leaching entirely out of question. Ores with a limestone gangue which, on leaching with dilute acids, form gelatinous silica or pack cement and form an impervious filter bed, may be treated with extreme ease by the use of ammonia.

For leaching a coarsely ground ore (16-30 mesh) containing appreciable percentages of the ammonia-soluble metal, the chlorination barrel, as designed by the Ammonia Cyanide Engineering Co., *non-lead lined*, with arched internal filter, is strongly recommended. It forms an absolutely ammonia-tight receptacle, easily charged and discharged, and in which agitation and washing-out of the ammonia

from the final tailings can be attained in a very thorough manner. Flights or baffles may be arranged on the inner periphery, thereby greatly aiding the agitation, with consequent rapid solution of the ammonia-soluble metal oxide. The company have also designed a special quartz filter for the purpose.

As to the treatment of slimes, that may be varied, dependent on the oxidized or sulphide condition of the material. In the one instance, simple agitation, in closed tanks arranged vertically with conical bottoms, plus subsequent primary decantation, to remove the greatest possible portion of the ammonia-metal solution, followed by adding wash water to dilute sludge to filtering density, which is then finally forced through a closed type filter apparatus of the Kelly, Burt, Sweetland, or other type of press, and the sludge well washed to free it from NH_3 . A large number of these filter machines are now being offered to the cyaniding profession, as is well known.

Sulphide copper slimes need a preliminary oxidation, or methods which latently render the copper mineral soluble in



CONTINUOUS BOILING-OUT APPARATUS.

leaching plant to operate on a copper-bearing sandstone near Hite, Utah, which is now being constructed. It is expected that the plant will start operation in the spring.

The Mosher-Ludlow process depends on the principle that ammonia, NH_3 , at the ordinary temperature forms soluble, stable compounds with the oxides, hydroxides or carbonates of copper, zinc, nickel or cobalt, such as $\text{Cu}(\text{NH}_3)_4$.

These ammonia metal compounds are readily dissolved by water containing a small excess of ammonia over that required to form the soluble compound. This is the leaching step of the process.

The precipitation step of the process depends on the fact that those soluble ammonia-metal compounds break up with great ease at the boiling point of water into the oxide or hydrate of the metal, which almost instantly settles as a heavy precipitate, while the ammonia, originally combined, is set free, to be reabsorbed in cold water or boiled-out solution for use over and over again. While the process will be described here in its application to copper ore, it is equally applicable to zinc, nickel and cobalt.

an ammonia solution. There is still room here for a great deal of work.

Due to the very powerful oxidizing action of a solution of cupric oxide (CuO) in ammonia, unoxidized silver minerals may be attacked and finally dissolved in the *raze* state, obtaining in this manner a percentage of extraction out of this character of mill product entirely impossible by ordinary cyanide methods.

With the standard roasting methods it is claimed that practically every known copper, zinc or nickel ore may be adapted to ammonia-cyanide methods of ore treatment; ammonia yielding a very high percentage from the properly roasted ore and a high-grade product of extreme purity.

It is, of course, of the greatest importance to have a thoroughly ammonia-tight equipment so as to hold the loss of ammonia down to the lowest possible limit. This is even of greater importance in the second half of the process, which comprises the boiling out of the ammonia solution. As mentioned before, the copper oxide is hereby precipitated. This commands an independent market of its own. Since the ammonia solution of copper is practically free from lead, antimony, iron and all injurious elements, it precipitates a copper oxide which is almost chemically pure.

As mentioned above in connection with the Schnabel process, Mr. D. Mosher recognized at an early state that the solution of the various mechanical difficulties involved in boiling out the solution and precipitating the copper oxide would be of first importance, and that it demanded highest engineering skill of an ammonia engineering specialist. He therefore approached some years ago Mr. James D. Ludlow, an expert refrigeration and mechanical engineer and chief designer for the Vulcan Iron Works of San Francisco. Mr. Ludlow first suggested the *continuous* boiling-out process, which Messrs. Mosher & Ludlow then worked out.

It may be compared in some way to the artificial ice and cold-storage industry in which ammonia water is boiled in a still, the ammonia gas distilled off, liquefied under pressure by powerful pumps, then permitted to expand, by which the cooling effect is produced, and finally reabsorbed in cold water to commence the same cycle of action over and over again. A slight mechanical loss of ammonia has to be continuously replaced, amounting to a small operating expense. In the ammonia-cyanide process no pressure is used and only dilute ammonia solution.

The general scheme of the Mosher-Ludlow continuous boiling-out apparatus is shown in the adjoining diagram. The chief feature is that the greatest care has been taken in its design to prevent the loss of ammonia and to reduce the quantity of heat consumed in boiling to a minimum. This is accomplished by a perfect system of heat interchange; the incoming cold ammonia-copper solution is brought in contact with the heat of the ammonia-steam vapor in the cooler and condenser and in the heat exchanger on its way to the boiling-out still, with the overflowing boiled-out solution. It will thus be seen that an important part of the heat applied to boil out the ammonia is passed to the incoming solution, thus saving steam and fuel.

The ammonia solution is at all times handled in closed vessels, and the same water is used over and over, so that if any copper or ammonia remains in solution after boiling there is no loss. The continuous feature of the apparatus allows of the use of comparatively small vessels, and permits of the heat exchange to the best advantage. The course of the solution through the apparatus will be easily seen from the diagram in connection with the following description.

The ammonia-copper solution is taken from the copper-solution tank and pumped through inner coil of the double-pipe counter-current cooler; thence it passes to the heat exchanger, thence to the boiling-out still, thence into exchanger, where part of its heat is passed to the incoming solution; thence to the settling tanks, where the precipitate (almost pure

copper oxide) is allowed to settle, the liquid being drawn off into the sump tanks. From the sump tanks the boiled-out solution is pumped through a cooler up to the boiled-out solution tank. From there it is used as needed to make fresh ammonia solution, and as wash water.

The ammonia and steam vapor from the boiling-out still passes up to the cooler and condenser into the annular spaces between the two pipes, parting with a fraction of its heat to the ammonia-copper solution in the inner pipe. From the cooler and condenser the ammonia water flows into the ammonia solution tanks, where it is diluted and is ready to be sent to the leaching system. A supply of cold water is kept flowing over the outside of the cooler and condenser and the boiled-out solution cooler. The precipitate is removed from the settling tanks from time to time, depending on the accumulation.

The first cost of the continuous boiling-out apparatus complete, including all steel tankage, piping, pumps, etc., is stated to be about \$6,000 for a plant of 100 tons capacity. As to the fuel required in boiling out a solution containing ammonia and copper, the following figures are given by the company.

The fuel required in boiling out 2 per cent ammonia-copper solution on a 100-ton (24-hour basis), and precipitating the copper as black oxide = 79.8 per cent Cu , may be found as follows:

One hundred tons solution are equivalent to 25,000 gallons water, of which, at the utmost, 10 per cent has to be evaporated during boiling to drive out most of the ammonia. Besides the 10 per cent evaporation (2,500 gallons) water, 2 per cent NH_3 , equivalent to 5,000 pounds anhydrous ammonia, will also demand a certain amount of heat to drive it over. Further, the whole 25,000 gallons solution have to be heated from 70°F . to 212°F . The total heat required for these purposes is 51,083,000 B. T. U., of which, however, according to experience, 60 per cent are saved by the heat exchanger, so that the net heat required amounts to 34,333,000 B. T. U.

In practice this required heat can be obtained from $1\frac{1}{2}$ to 2 tons of a good coal, and with a boiler of from 35 to 40 hp.

In view of the complete success of ammonia, cold-storage plants in beef-packing plants, breweries, etc., it would appear that the ammonia cyanide process, as sketched above, should not involve exaggeratedly great difficulties if only the apparatus is properly designed and installed. On the other hand, the process apparently solves some important metallurgical problems, like the treatment of such copper, gold ores and tailings as have heretofore yielded no profitable returns by other systems of treatment. Oxide and carbonate ores yield very readily to the process.

Similar, as in cyaniding, the process may be applied after the stamp mill and concentrating table have done their work, and have still left sufficient values to be profitably treated by a subsequent leaching.

Classification of sands and slimes, as well as of sliming methods, may be adopted, depending on whichever gives the more economical system of treatment.

Through the very energetic oxidizing action of a copper oxide-ammonia solution, sulphide silver ores, with ruby silver, stephanite, argentite, etc., will give a more thorough extraction by ammonia-cyanide methods than is possible by plain cyaniding. In many instances where chloridizing-roasting and "hypo" leaching is applied it is claimed that extraction by this process will be just as effective on the raw ore and thereby avoid the cost of roasting.

It will certainly be of interest to await the results to be obtained at the first plant which, as noticed before, is soon to be opened in Utah.

The Kny-Scheerer Co. were among the many concerns which suffered heavy losses during the recent fire of the Parker Building. Fortunately, a few months before, the laboratory supplies department had been moved to the factory of the company at Ninth Avenue and Twenty-Seventh Street, New York, where the main offices are now also located.

Notes.

Messrs. Geo. D. Feidt & Co. (successors to Bullock & Crenshaw), manufacturers and dealers in chemical apparatus and chemical supplies, at present located at 528 Arch street, Philadelphia, will move on or about May 1 to new quarters, at 29-31 North Seventh Street.

Centrifugals, Extractors and Separators.—The D'Olier Engineering Co., of Philadelphia, have sent us their illustrated pamphlets on centrifugal and turbine pumps and on electric-motor-driven centrifugals, extractors and separators for syrup, water, liquor and oil extraction, etc.

Fixation of Atmospheric Nitrogen.—The Tesla Nitrates Co. has been organized at Portland, Me., for the purpose of producing nitrogen compounds by an electric process of Nicola Tesla from atmospheric air. The company is capitalized at \$500,000, and the officers are James E. Mantor, Portland, president, and Clarence E. Eaton, Portland, treasurer.

Book of Chemical Labels.—We have received from the Kny-Scheerer Co., of New York City, a copy of their new label book, which has been prepared by Dr. Herbert Raymond Moody. The advantage of using uniform labels in laboratories is evident. Although an absolutely universal set cannot well be printed, this collection, which provides printed labels for all ordinary reagents and the more common chemicals used for general purposes in well equipped laboratories, will undoubtedly meet a demand. The book contains some 450 printed labels besides a number of blank labels. The price of the book is 35 cents for single copies and 25 cents each if ordered in larger quantities.

Blowers and Exhausters.—The J. B. & J. M. Cornell Co., of New York City, have just issued an illustrated pamphlet on their pressure blowers and exhausters. The claims of the manufacturers are that greater volume and higher pressure are produced with less horsepower than by any other type. The blowers are designed specially for use in connection with cupola furnaces and forges, and for producing mechanical draft for steam boilers, sand blasts, pneumatic tube delivery, or for any purpose where high pressure combined with large volume is desired. The pamphlet gives a concise, illustrated description of the chief features of construction of Cornell blowers and exhausters and tables of dimensions.

Water-Jet Primers.—While steam-jet primers are extensively used for priming syphon pipes, centrifugal pumps, long suction pipes of piston pumps and air vessels, there are cases in which they cannot be used on account of steam not being available; for instance, where the pumping station is driven by gas engines or located too far from the boiler plant. As water is always available in a pumping station, water jets are useful in such cases. The Schutte & Koerting Co., whose steam-jet primers and water-jet primers are widely in use, describe in a recent illustrated pamphlet the construction, installation and operation of water-jet primers. This company also make automatically working water-jet primers. The jet apparatus is installed inside of the vessel, and the pressure water is started automatically by a float when the water level decreases, evacuating until the water has risen to the proper height, when the water supply is automatically shut off by means of a float-actuated water pressure valve.

Messrs. E. H. Sargent & Co., of Chicago, have recently issued a supplementary price list of their chemical apparatus and assayers' supplies. This is a supplement to their general chemical catalog of 1905, covering a great number of new or improved apparatus and designs which have come out since that time. Among them are Sargent's distilling apparatus, Camp's shaking machine, Morehead's gas apparatus, electric hot plates, electric ovens, electric furnaces, electric thermostats and pyrometers. The catalog is arranged alphabetically and well illustrated.

Thermit for Repair Work.—A neat pamphlet recently issued by the Goldschmidt Thermit Co., of New York City, gives shop instructions for the use of thermit in repair work. The instructions are given in a very concise yet complete manner, so as to be easily understood. Among the different applications for which special instructions are given are the repairs of locomotive drivers, repairs of connecting rods, repairs of electric motor cases (a new and very interesting application of thermit), repairs of flaws in castings and repairs on larger sections. A number of instructive diagrams and illustrations is given.

Pyrometers.—Catalog No. 20, recently issued by William H. Bristol, 45 Vesey Street, New York City, deals with electric pyrometers for blast furnaces (indicating, recording and combination outfits) for temperatures of hot blast and top gas. The indicating instrument is for the use of the attendant at the furnace, the recording instrument for use of the superintendent in his office, while a portable instrument is provided for general tests. The different types of pyrometers are concisely described. The catalog is profusely illustrated.

Wood Pipe.—In a recent circular of the A. Wyckoff & Son Co. the following advantages are claimed for their wood pipe, which is made by special method, with careful selection of the finest white pine. The wood pipe is cheaper than metal pipe. Owing to its lighter weight it costs less to transport and lay. It can be laid nearer surface, thereby saving the expense of a deep trench, and unskilled labor can handle it. It is not injured by acids, fumes, sulphur or other poisonous impurities. It does not rust. Salt water does not affect it and vegetable matter does not clog it. It is more durable than either wrought iron or steel, and under proper conditions it is as durable as cast iron. It is made to stand all pressures up to 160 pounds.

Spiral Riveted Pipe.—The American Spiral Pipe Works, of Chicago, Ill., have recently issued a fully illustrated pamphlet on the various uses, advantages and economies of Taylor's spiral-riveted pipe, forged steel pipe flanges, etc. The spiral-riveted pipe is intended especially for pressure purposes. When such pipe is tested to the bursting point, the rupture always occurs in the solid metal, demonstrating the spiral riveted seam to be the strongest part of the pipe. In addition to its enormous bursting strength, spiral-riveted pipe has exceptional strength for resistance of collapsing under vacuum or heavy earth fills. This pipe is also extensively employed for hydraulic mining and sluicing work in connection with giants or nozzles. For exhaust steam purposes the galvanized flanged pipe is in extensive use.

The Taylor Instrument Companies, a new corporation, of Rochester, N. Y., is the outgrowth of the thermometer business established in 1851 by George Taylor. In the middle of the sixties the firm became Taylor & Richardson, in the early seventies Taylor Bros., and in 1890 the firm was incorporated as Taylor Bros. Co. Since then the company has acquired the business of the Hohmann & Maurer Manufacturing Co., makers of high-grade thermometers and gauges for industrial purposes; the Watertown Thermometer Co., makers of general thermometers and thermometers for advertising purposes; the R. Hoehn Co., makers of commercial thermometers and hydrometers; Short & Mason, Ltd., of London, England, makers of barometers, compasses, meteorological and surveying instruments; the H. & M. Automatic Regulator Co., owners of valuable patents on temperature and pressure regulation and control for domestic and industrial purposes, and recently the American branch of the renowned Cambridge Scientific Instrument Co., of Cambridge, England, whose pyrometers and measuring instruments in general have a world-wide reputation. One of the latest achievements of the latter company is, as our readers know, a radiation pyrometer, which may be used as indicating as well as recording instruments.

Tungsten.—Messrs. Geo. G. Blackwell, Sons & Co., Ltd., of Liverpool, have erected at Garston, a suburb of Liverpool, a new works for the manufacture of alloys and metals, and particularly tungsten metal, for the steel trade. It is stated to be 96 to 98 per cent pure and practically free from carbon. The tungsten ore comes from Portugal and Australia. They also make ferro-tungsten, containing 80 to 86 per cent tungsten with $\frac{1}{2}$ to 1 per cent carbon and other lower grades.

Mr. John Fritz, of Bethlehem, Pa., the well-known metallurgical engineer and veteran iron master, has been elected a member of the board of trustees of Lehigh University, and has accepted the position. His universally recognized high standing among the engineers of the country makes this addition to the board of trustees of this technical institution eminently fitting.

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

CALCIUM CARBIDE (Continued.)

651,167, June 5, 1900, James E. Hewes, Baltimore, Md. Assignor to the Provident Life & Trust Co., trustee, of Philadelphia, Pa.

Calcium carbide is produced by smelting a mixture of coke and lime in a rectangular furnace having a hinged rear wall, in the lower portion of which is set a carbon block which is not connected in circuit. Two horizontal parallel electrodes of opposite polarity rest upon the bottom of the furnace, means being provided for retracting them longitudinally. To initiate the reaction the two electrodes are brought into contact with the carbon block, thereby closing the circuit; they are then retracted to form two arcs in series between the respective electrodes and the block. As the carbide is produced the electrodes are retracted until a block or mass of carbide is produced; the hinged rear wall is then dropped and the carbide extracted from beneath the unconverted charge.

651,916, June 19, 1900, John Zimmerman and Isidore S. Premer, of Chicago, Ill.

The furnace comprises a rectangular chamber having a tilting hearth disposed above the bottom. Opposed electrodes, in arcing relation, enter the furnace above the hearth through opposite side walls. A casing carrying a hopper and containing a compressing screw projects into the furnace opposite the gap between the electrodes, the arrangement being such that a mixture of lime and carbon fed to the casing may be gradually passed into the arc. The mixture is preferably in the form of a stiff paste, with or without a binder, such as borax, graphite and iron, or molasses, but it is stated that the process may be successfully operated without the use of a binder. In order to support the mixture between the aperture of the casing and the arc an apparatus is provided for feeding beneath the mixture and forwardly to the arc stiff paper or cardboard, the construction being such that the rate of movement of the cardboard support is the same as that of the charge to be smelted. It is alleged that the process is continuous and economical with respect to the loss of heat. The carbide is discharged into the bottom of the furnace at intervals by tilting the hearth.

652,877, July 3, 1900, Richard Charles Baker, London, England.

By the reduction of calcium borate by means of carbon in presence of iron, nickel, chromium, tungsten or compounds of these metals, calcium carbide is produced simultaneously with ferro-boron, nickel-boron, chromium-boron, or tungsten-boron. The specification refers to the use of the above-mentioned boron alloys for alloying with steel.

NEW BOOKS

A TREATISE ON CHEMISTRY.—By Sir H. E. Roscoe and C. Schorlemmer. Two vols. Vol. II., the metals. New edition completely revised by Sir E. Roscoe and Dr. A. Harden. 1,448 pages; illustrated. Bound in cloth. Price, \$7.50 net. New York: The Macmillan Co.

STOICHIOMETRY.—By Sydney Young; together with an introduction to the study of physical chemistry by Sir W. Ramsay. (Describing the laws of chemical combination, then gives a detailed account of the properties of gases, and then proceeds to a discussion of the methods of determining atomic weights.) 442 pages; 88 illustrations. Bound in cloth. Price, \$2. New York: Longmans, Green & Co.

INORGANIC CHEMISTRY.—By E. I. Lewis. 424 pages. Bound in cloth. Price, \$1.25 net. New York: G. P. Putnam's Sons.

TECHNICAL METHODS OF ORE ANALYSIS.—By Albert H. Low. Third edition, revised and enlarged. 356 pages. Bound in cloth. Price, \$3. New York: John Wiley & Sons.

LABORATORIUMSBUCH FÜR DEN METALLHÜTTENCHEMIKER.—By H. Nissenon and W. Pohl. Vol. II.; 86 pages. Paper cover. Price, Marks, 3. (Retail price in New York, \$1.) Halle a. S.: Wilhelm Knapp.

THE UTILIZATION OF WOOD WASTE BY DISTILLATION.—By Walter B. Harper. A general consideration of the industry of wood distilling, including a description of the apparatus used and the principles involved, also methods of chemical control and disposal of the products. 166 pages; illustrated by 74 engravings. Bound in cloth. Price, \$3. St. Louis, Mo.: St. Louis Lumberman.

MODERN PIGMENTS AND THEIR VEHICLES.—By F. Maire. Their properties and uses, considered mainly from the practical side, and how to make tints from them. 275 pages. Bound in cloth. Price, \$2. New York: John Wiley & Sons.

FERTILIZERS.—By E. Burnett Voorhees. The source, character and composition of natural, home-made and manufactured fertilizers, and suggestions as to their use for different crops and conditions. Tenth edition. 349 pages. Bound in cloth. Price, \$1.25 net. New York: Macmillan Co.

TEXT-BOOK ON PAPER MAKING.—By C. F. Cross and E. J. Bevan. Third edition, partly rewritten with new matter. Bound in cloth. Price, \$5. New York: Spon & Chamberlain.

THE MINER'S GEOLOGY AND PROSPECTOR'S GUIDE FOR MINING STUDENTS, MINERS, PROSPECTORS AND EXPLORERS.—By G. A. Corder. 237 pages; illustrated. Bound in cloth. Price, \$2. New York: Spon & Chamberlain.

MINING TABLES.—By F. H. Hatch and E. J. Vallentine. Being a comparison of the units of weight, measure, currency, mining area, etc., of different countries, together with tables, constants and other data useful to mining engineers and surveyors. 208 pages. Bound in cloth. Price, \$1.90 net. New York: The Macmillan Co.

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THE SPECTROSCOPE.—By T. Thorne Baker. Its uses in general analytical chemistry; an intermediate text-book for practical chemists. Well illustrated. Bound in cloth. Price, \$1.75 net. New York: William Wood & Co.

A SCHEME FOR THE DETECTION OF THE MORE COMMON CLASSES OF CARBON COMPOUNDS.—By Frank E. Weston. New edition, having been somewhat revised. 103 pages. Price, 90 cents. New York: Longmans, Green & Co.

LES DECOUVERTES MODERNES EN PHYSIQUE.—By O. Manville. 186 pages; 32 illustrations. Paper cover. Price, 5 francs (retail price in New York, \$1.35). Paris: Librairie Scientifique, A. Hermann.

A LABORATORY GUIDE FOR STUDENTS IN PHYSICAL SCIENCES.—By H. Schapper. 66 pages, bound in cloth. Price, \$1. New York: John Wiley & Sons.

THE GAS ENGINE IN PRINCIPLE AND PRACTICE.—By Arthur H. Goldingham. 195 pages; illustrated. Bound in cloth. Price, \$1.50 net. New York: Spon & Chamberlain.

POWER AND POWER TRANSMISSION.—By Eugene W. Kerr. A work designed for elementary instruction in colleges and manual-training schools. Second edition revised. 380 pages; illustrated. Bound in cloth. Price, \$2 net. New York: John Wiley & Sons.

HANDBOOK OF STEAM AND ELECTRICAL ENGINEERING.—By H. C. Tulley. 1,000 pages; illustrated. Price, \$3.50. New York: Hill Publishing Co.

AN INTRODUCTION TO THE STUDY OF ELECTRICAL ENGINEERING.—By H. H. Norris. 409 pages; illustrated. Price, \$2.50. New York: John Wiley & Sons.

MODERN VIEWS OF ELECTRICITY.—By Sir Oliver Lodge. 532 pages; illustrated. Price, \$1.25 net. New York: Macmillan Co.

THEORETICAL MECHANICS.—By A. E. H. Love. An introductory treatise on the principles of dynamics, with applications and numerous examples. Second edition. 383 pages; illustrated by diagrams. Bound in cloth. Price, \$3.00. New York: G. P. Putnam's Sons.

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TECHNICAL THERMODYNAMICS.—By G. A. Zeuner. Translated from the fifth complete and revised edition of "Grundzüge der mechanischen wärmetheorie," Jos. Frederic Klein. Contents: Vol. 1, Fundamental Laws of Thermodynamics, Theory of Gases; Vol. 2, The Theory of Vapors. Vol. 1, 460 pages; Vol. 2, 556 pages; illustrated. Price, \$8.00 net. New York: D. Van Nostrand Co.

SUPERHEAT, SUPERHEATING AND THEIR CONTROL.—By W. H. Booth. 170 pages; illustrated by tables and diagrams. Price, \$1.50 net. New York: D. Van Nostrand Co.

THE GAS ENGINE.—By F. R. Hutton. Third edition revised. Bound in cloth. Price, \$5.00. New York: John Wiley & Sons.

TABLES OF THE PROPERTIES OF STEAM AND OTHER VAPORS AND TEMPERATURE-ENTROPY TABLE.—By Cecil H. Peabody. Seventh edition, rewritten. 136 pages. Price, \$1.00. New York: John Wiley & Sons.

STEAM TURBINES.—By Carl C. Thomas. Third edition revised and enlarged. 347 pages; illustrated. Price, \$4.00. New York: John Wiley & Sons.

STEAM TURBINES.—By Lester G. French. 340 pages; illustrated. Bound in cloth. Price, \$3.00. New York: Hill Publishing Co.

PEAT, ITS USE AND MANUFACTURE.—By P. R. Björling and F. T. Gissing; illustrated. Price, \$2.00 net. Philadelphia: J. B. Lippincott & Co.

REINFORCED CONCRETE.—By Walter L. Webb. A treatise on cement, concrete and concrete steel and their applications to modern structural work. 129 pages; illustrated by plates and diagrams. Price, \$1.00. Chicago: American School of Correspondence.

SCIENCE AND HYPOTHESIS.—By Jules Henri Poincaré, with a preface by Jos. Larmor. The author gives a Socratic exposition of the limitations of the human outlook on the universe, but he does not count these limitations as imperfections, and he leaves the reader with a wide conception of the wonderful fabric of human knowledge. He shows that all thinkers and experimenters need hypotheses from which to start to study out different theories of the world as a whole. The mathe-

matics of the book require a trained reader. 271 pages. Price, \$1.25 net. New York: Charles Scribner's Sons.

PRACTICAL INTEGRATION.—For the use of engineers, etc. By A. S. Percival. 86 pages. Price, 80 cents net. New York: The Macmillan Co.

EVERY-DAY LAW; OR THE LAW OF CONTRACTS.—By Rob. C. Strong and C. B. Denson. 355 pages. Price, \$2.50. Raleigh, N. C.: Edwards & Broughton.

A HISTORY OF POLITICAL ECONOMY.—Second edition. By J. K. Ingram. 203 pages; illustrated. Price, \$1.50 net. New York: The Macmillan Co.

ESSENTIALS OF ECONOMIC THEORY AS APPLIED TO MODERN PROBLEMS OF INDUSTRY AND PUBLIC POLICY.—By J. Bates Clark. 580 pages; illustrated by diagrams. Price, \$2.00 net. New York: Macmillan Co.

AGRICULTURE.—A list of valuable Government papers on live agricultural topics. 87 pages. Paper cover. Washington, D. C.: Government Printing Office.

ADVANCE CHAPTERS FROM MINERAL RESOURCES OF THE UNITED STATES FOR 1906. Washington, D. C.: United States Geological Survey.

THE PRODUCTION OF ABRASIVE MATERIALS IN 1906.—By Douglas B. Sterrett. 16 pages.

THE PRODUCTION OF SULPHUR AND PYRITE IN 1906.—By David T. Day. 10 pages.

THE PRODUCTION OF LEAD IN 1906.—By J. M. Boutwell. 23 pages.

THE PRODUCTION OF FLUORSPAR AND CRYOLITE IN 1906.—By Ernest F. Burchard. 9 pages.

THE PRODUCTION OF QUICKSILVER IN 1906.—By J. M. Boutwell. 13 pages.

EXPERIMENTAL ELECTRICAL ENGINEERING AND MANUAL FOR ELECTRICAL TESTING; for engineers and for students in engineering laboratories.—By V. Karapetoff. 800 pages; illustrated. Bound in cloth. Price, \$6 net. New York: John Wiley & Sons.

THE STORY OF IRON AND STEEL.—By Jos. R. Smith, 205 pages. Bound in cloth. Price, 75 cents net. New York: Robt. Appleton Co.

BRITISH INDUSTRIES.—By W. Ja. Ashley. A series of general reviews for business men and students. Second edition. 249 pages. Bound in cloth. Price, \$1.80 net. New York: Longmans, Green & Co.

THOMAS ALVA EDISON.—By Francis Arthur Jones. Being sixty years of an inventor's life; with numerous illustrations from photographs. ("The author not only knows Edison intimately, but in the preparation of his book received the co-operation of many of Edison's friends, who gave him some very human details of the inventor's early life. The story reads like a romance. After years of struggle for a bare existence he was at twenty-two a full-fledged inventor, having sold his stockticker for \$40,000. After this start the quadruplex telegraph, the dynamo, the incandescent lamp, the phonograph, the kinctoscope, etc.) 390 pages; many illustrations. Bound in cloth. Price, \$2 net. New York: Thomas Y. Crowell & Co.

BOOK REVIEWS.

DIE ENGLISCHEN ELEKTROCHEMISCHEN PATENTE. By Dr. P. Ferchland, patent attorney in Berlin. Vol. I: Electrolysis (Vol. XXIX of the German Monographs on Applied Electrochemistry). 176 pages; many illustrations. Price, marks 9.00 (retail price in New York, \$3.00). Halle a. S.: Wilhelm Knapp.

This is the first of two volumes in which brief, concise abstracts are given of all English electrochemical patents. This first volume comprises the electrolytic patents. Their number

appears to be well over 1,000, to make a rough estimate. They are arranged simply in chronological order, the oldest English electrolytic patent having been granted in 1842, for the deposition of metals, especially platinum. The abstracts go down to the beginning of 1906. A subject index and a name index enable one to quickly find what is wanted. As a reference book the volume will be very useful.

* * * *

LES DECOUVERTES MODERNES EN PHYSIQUE. By O. Manville. 186 pages; 32 illustrations. Price, 5 francs (retail price in New York, \$1.35). Paris: Librairie Scientifique, A. Hermann.

This book discusses in concise manner the theory of "modern physical discoveries" in their relation to the hypothesis of the electric constitution of matter. The author shows that the electronic theory is nothing but a mechanical theory. While the "mechanical theory of yesterday" tried to explain the physical phenomena "in general, and especially the electric ones by the matter and its movement," the theory of to-day tries to explain everything by "the electricity and its movement."

The book discusses the passage of electricity through liquids and gases, the ionization of gases, electrons, the radioactive substances, the radioactivity of matter and the electronic theory of matter.

* * * *

THE METRIC AND BRITISH SYSTEMS OF WEIGHTS, MEASURES AND COINAGE. By F. Mollwo Perkin, Ph. D., Head of Chemistry Department, Borough Polytechnic Institute, London. 83 pages; 17 diagrams. Price, 50 cents net. London: Whittaker & Co.

This is a small book, primarily written "with the hope that those engaged in teaching chemistry, physics, engineering or general elementary science [in English schools and colleges] may find it useful to put into the hands of their students" as a connecting bridge from the British system of measures, weights and coinage to the metric decimal system. The hope is also expressed that the book "will be found useful to the business man and to the general public."

The keynote of the presentation of the subject in this book is simplicity. The author constantly endeavors to present the matter in the easiest possible way, to explain it by diagrams, and to give to his British-American readers a clear, concrete idea of the metric measures. Thus as a help to remember the length of a meter it is stated "that it is slightly longer than the yard, or the length is 3 feet 3 inches and $\frac{1}{3}$ of an inch. This is easily remembered by bearing in mind 333." Further, to give an idea of the length of a decimeter, reference is made to the cricket pitch, which is almost exactly 20 meters, or 2 decimeters. To give an idea of the length of a hectometer, it is stated that the length of an ordinary English football field between the goal posts is nearly 1 hectometer and the width about $\frac{1}{2}$ hectometer.

There is little to criticize. Why on page 11 a distinction is made between "Bulk: cubic meter, divided into 1,000 cubic decimeters," and "Capacity: liter, divided into 1,000 cubic centimeters," is not clear to the reviewer. Certainly it should be expressly stated at this place that 1 cubic decimeter is a liter.

The author arranges his subject by first taking up measures of length and of area, then weights and then volumes. Logically, the volumes should come before the weights, since the unit of weight is based upon that of volume and not reversely. Three further chapters on specific gravities, temperature measurements and money should prove useful.

Lord Kelvin said almost a quarter of a century ago: "I look upon our English system as a wickedly brain-destroying piece of bondage under which we suffer. I say this seriously. I do not think any one knows how seriously I speak of it."

The author of the present book says of the present situation

in England: "At present it seems very difficult to get a bill through Parliament the object of which is to make the metric system compulsory, but surely it would be possible to pass a bill which would make the teaching of the system compulsory in every school in the land." Indeed, this would be a magnificent beginning.

* * * *

TRANSACTIONS OF THE AMERICAN ELECTROCHEMICAL SOCIETY, 1906.—Vols. IX. and X., meetings at Ithaca and New York City.

It may be of interest to our readers to hear what the *Electrical Review*, of London (which journal brings often good and concise notes on electrochemical engineering subjects), has to say on the *Transactions* of the American Electrochemical Society, since it is always useful to learn how others see us:

"The *Transactions* of the vigorous and enterprising American Electrochemical Society continue to be of the same varied interest and value that has characterized them since the very first issue, and, we may add, they are no less strong on the practical and experimental side, as they are—well, a little uncertain, let us say—on the theoretical side, than they ever have been. A list of the names of the fifty papers or thereabouts in these two volumes would probably come as a surprise to many people in this country who little realize the wide field that practical electrochemistry now covers. We cannot, of course, in a brief review do more than just draw attention to one or two of the more noteworthy out of a whole host of interesting papers. An important and most capable paper is a theoretical "Study of Resistance Furnaces," by Mr. C. L. Collens, in which the author deduces some general equations that should prove of considerable value to those engaged in the design of this type of furnace. A paper by Mr. E. A. Ashcroft on "Sodium Production" describes, in as much detail as the exigencies of business considerations will allow, his own very ingenious process. In this, unlike the Castner process, which now practically holds the field, and in which caustic soda is the electrolyte, the universal common salt is the raw material. This is electrolyzed in a double apparatus, in the first of which the sodium alloys with molten lead, while the clever device of setting up a strong magnetic field in the cell maintains the liquid cathode and the electrolyte in circulation. Mr. Sperry's note on "Electrochemical Processes as Station Load Equalizers" raises points well worthy of the consideration of electrical engineers who are worried by peaks. The electric vacuum furnace, which Mr. Aisem, of the American G. E. C., describes, is a new type of furnace now coming into use both as an instrument of research and for some small industrial processes. A suggestive paper by Prof. C. F. Burgess and Mr. O. P. Watts discusses the structure of electro-deposited metals, but it deals only with the outskirts of the subject, and we still await a really comprehensive study of a matter second in importance to none with which the electrometallurgist has to concern himself. There are now several electrochemical laboratories in England, and a subject such as this is pre-eminently suitable for research students to tackle under able guidance. A controversial paper by M. Le Blanc discusses the possibility of depositing by electrolysis thick layers of coherent metallic chromium, and the author concludes—a conclusion not shared by his critics—that this cannot be done. Of broader interest are several useful papers on "Pyrometry," and, lastly, we have a detailed description by Prof. Crocker of an improved and quite business-like variety of primary battery of the bichromatic type, made by Mr. F. A. Decker, which, judging by the tests submitted, should help to popularize the use of batteries in those many cases where their trouble and cost at present put them out of court.

"Altogether, the varied fare provided in these *Transactions* is well worthy of careful study by everybody who wishes to be posted in what practical electrochemistry is doing in the most go-ahead country in the world."

Electrochemical and Metallurgical Industry

VOL. VI.

NEW YORK, APRIL, 1908.

NO. 4.

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the

ELECTROCHEMICAL PUBLISHING COMPANY

239 West 39th Street, New York

EUROPEAN OFFICE, HASTINGS HOUSE, NORFOLK ST., STRAND, LONDON, ENG.

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Yearly subscription price for United States, Mexico and United States dependencies, \$2.00; for all other countries, \$2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, APRIL, 1908.

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Date of Mailing.

Beginning with this issue, this journal will be mailed regularly from New York City on the 26th of each month. The intention is to have the journal delivered even to our Western readers on or before the first of the month which is printed on the cover.

Albany Meeting of the American Electrochemical Society.

On another page our readers will find the preliminary program of the annual meeting of the American Electrochemical Society to be held in Albany, Schenectady and Troy on the last day of April and the first days of May. While the General Electric works at Schenectady are, of course, of dominating importance in determining the technical and engineering character of the neighborhood, it is by no means without purely electrochemical interest. It was from Mr. Anson G. Betts' laboratory, in Troy, that electrolytic lead refining started on its course of victory around the world. An electrolytic plant for sodium chloride electrolysis in a paper mill in Mechanicville is an interesting example of the growing tendency of Eastern paper and pulp mills to erect their own electrolytic works. Besides, considerable work relating to electrochemistry has been carried out at the works of the General Electric Company. The preliminary program, issued six weeks in advance of the meeting, is already so attractive that we may with certainty look forward to a well-attended, enjoyable and profitable meeting.

The Iron and Steel Industry.

There is no law entering into the common affairs of men of such wide application as the law of compensation. Its powers of bobbing up and asserting itself in the most unexpected places is a source of constant surprise. Only too often we find it showing its effect in a case where we thought we had scored an advantage, only to find that it brings to us a corresponding disadvantage. The iron and steel industry is feeling the effect of this law in its unpleasant aspect. Some time ago there was established in the trade an "era of steady prices." From this rule, much was expected and much was realized. For a period of almost three years, or from the beginning of 1905 until the end of October last, the industry ran to its utmost capacity, despite the fact that the capacity constantly increased. In January, 1905, pig iron was being produced at the rate of 21,250,000 tons a year. In October, 1907, pig iron was being produced at the rate of 28,000,000 tons a year. In each month the available furnace capacity of the country was being pushed substantially to its limit. There were absolutely new blast furnaces completed and blown-in between Jan. 1, 1905, and Oct. 31, 1907, having an annual capacity of about 4,820,000 tons. The remainder of the increment in production was brought about through better methods of operation and through the re-

building and otherwise improving of many furnaces. Consumption of pig iron and scrap by steel works, iron mills and iron foundries was on a par with the blast-furnace activity.

* * *

Never before in the history of the American iron trade had there been such an extended record of complete activity. Never before, even with complete activity, had production attained anything like such a rate. In the two years and ten months from Jan. 1, 1905, to the end of last October, there were produced more than 70,000,000 tons of pig iron. In the eight and a half years from the middle of 1888 to the end of 1896, a period just three times as long, the production was a trifle less than 70,000,000 tons. In that earlier period, it may be stated with confidence, the American people were not in the stone age, nor yet in the bronze age. From the middle of the former to the middle of the latter period, the population increased only by 30 per cent. To the adoption of iron for new uses, to its wider adoption for old uses, to the growth in population, and to a limited extent to the increase in exports, was probably due in great measure the attainment of the high rate of production in this late period, but in a measure the high rate was attributed also to this era of steady prices, and to this force alone was attributed the maintenance of the maximum possible rate for so long a time. Undoubtedly this judgment ascribing the honor to the era of steady prices was correct. They had an important influence, that of maintaining a steady demand where, under the old rule of constantly fluctuating prices, demand was irregular. But it is one thing to discover a law applicable over a certain range of events or conditions, and another to write a law applicable over the entire possible range. The law discovered was applicable only to the existing period, however long or short that period might prove to be; in other words, it did nothing but explain the phenomena after they had been observed; it could do nothing towards predicting phenomena. The phenomenon has been observed that whereas last October pig-iron production was at a rate of 28,000,000 tons a year, it dropped on Jan. 1 to a rate of 12,500,000 tons, and has since increased to about 14,000,000 tons, with no prospect of any material improvement in the near future, and all this despite the fact that there are new furnaces partially completed which could increase the rate of last October to about 32,000,000 tons.

* * *

The iron trade is now experiencing the operation of this law of compensation. What the era of steady prices did was not so much to create demand as to induce buyers to anticipate their requirements. Under the old order of things there were always those who chose to wait until the last moment before making commitments; finally they were forced to buy, and this event occurred sometimes in good times, sometimes in bad times. There were others who went with the majority, and bought when others were buying. In this era of steady prices the former class has been merged into the latter; all have bought. There has been an anticipation of requirements to an extent never before seen. There has been no occasion to delay making commitments if the prospective need lay anywhere in the near future, but if in the very distant future it is, of course, a very different matter. The guarantee of steady prices could extend only a certain distance ahead; how far ahead no one

could tell except by experiment. It would now appear that the experiment has been made and the result announced.

* * *

It seems to be clear that one of the influences of the era of steady prices in iron and steel has been to make men look farther and farther forward, taking what would otherwise have been a series of peaks in the curve of demand, bringing them back in point of time and endeavoring to fill them into what would otherwise have been small hollows in the curve. They were more than sufficient to fill the hollows, the result being that they spread out and raised the general level of the resulting smooth curve. The mathematical result of such a process would be to give the curve a more upward trend to the point where the bringing back process ceased, and to give it thereafter a more sharply downward trend, by reason of the greater height attained and the removal of the peaks which had been taken backward. This, it would appear, represents the situation to-day. There was anticipation of nearby and fairly far-off prospective wants, while now all anticipation has ceased, and the market is robbed both of the support which in a period of fluctuating prices could be expected from the short interest, which waits for a decline, and of the support coming from the backing up of a necessary demand, which in a period of moderately few months, in the old order of things, would have resulted in forced buying. Here we have the working of the law of compensation. Some of the good things we otherwise would have had now were forced back into the period just ended. We enjoyed them then, we must lack them now. The law of compensation can effect big swings as well as little swings. Doubtless there is being laid in this year, or in these two years, or in as long a period as this present situation may last, the foundation for another compensation which shall be correspondingly beneficial. The artifice which was expected only to remove the little vibrations has increased the amplitude and the wave length, and in the long run the whole result may be beneficial, but just now we are in an uncomfortably deep trough.



The Fumes from Chemical and Metallurgical Works.

As noticed in our last issue, Prof. Charles Baskerville, director of the Laboratory of the College of the City of New York, presented a most suggestive and interesting paper on the injury to vegetation by the fumes from chemical factories, at the February meeting of the New York section of the Society of Chemical Industry. Dr. Baskerville spoke from knowledge gained in years of experience as expert for the Virginia-Carolina Chemical Company, in which capacity he was employed to investigate the true conditions which obtained at several factories where alleged injury to vegetation was claimed. His advice was followed in settling genuine claims for damage done, or fighting suits which were unwarranted. The subject is of such general interest and importance that we wish to comment on it at greater length.

* * *

The devastation of the forests in the Ducktown, Tenn., Shasta County, Cal., and Natrona, Pa., districts, as shown by Haywood and Buckhout, appear to be uncontrovertible evidence of the ravages of smelter fumes. Manufacturers at times have undoubtedly shown an utter disregard for neighbors and the gases have been allowed to escape, which created havoc. These

should be dealt with speedily. The tracing of an injury to fumes, except, of course, in such flagrant cases referred to, is not easy. The proximity of a chemical works with some people is *prima facie* evidence of the cause of all the trouble. Freytag has stated that the "assumption of an invisible injury done to vegetation by the smelter works' vapors and the awarding of damages founded thereon are unwarranted." When smells characteristic of the factory are noted to the windward, the evidence to the lay mind is most convincing. Chemical factories do generate gases that are objectionable. None is surer of this than the manufacturer himself. Sometimes these gases are actually poisonous. Oftentimes they are not. But inasmuch as they "smell," they are objectionable. This constitutes a nuisance, and suits for alleged injury from chemical fumes have been a source of great annoyance to manufacturers in consequence. Even when poisonous gases escape by accident, or otherwise, they may be rendered comparatively harmless, if sufficiently diluted. We say "comparatively," for, as is well known, the sulphur gases from the combustion of coal in cities on a large scale, aided by soot, do produce slow, but far-reaching and constant injury to exposed works of art, libraries, draperies and decorations of our homes, as well as those in public repositories. Dr. Baskerville showed that sulphuric acid, calculated at 80 per cent, is produced to the extent of 1,300 tons daily in the atmosphere of New York City from the combustion of 9,000,000 tons of anthracite and 4,000,000 tons of bituminous coal per year. This is in addition to the soft coal supplied to steamships. And it has nothing to do with chemical works or smelters. It is simply the result of the amount of coal consumed regularly for heating and other purposes in New York City. From many determinations of the acidity of the air around factories, which, as a rule, are located in sparsely settled places, under all kinds of topographical and weather conditions, it has been learned that the acidity is often far less than that observed in large cities. Therefore, placing the blame upon chemical works has not always been a "square deal."

* * *

The growth of vegetation is affected by many factors, some happening in the ordinary course of events and others occurring only on extraordinary occasions. A weak and stunted growth, smaller leaves, shorter twigs, lack of normal green color indicates unfavorable conditions for growth. The inattentive multitude attribute such a state of affairs to "the drought," "the heat," "frost" or "blight," or "smoke," or "gases in the air." These "gases in the air" may come from legitimate sources, but it must be remarked that however perfect the smoke consumption may be, the sulphides are still in a large measure burned to the oxides of sulphur. This may be obviated only by the use of electrical energy or peat or wood or of producer gas for power and heating purposes. The former are out of the question now on the score of expense. Thirteen billion cubic feet of gas were sent out on the island of Manhattan in 1906. This gave only 230 tons of sulphuric acid into the air, a minor item when we contemplate the other figures. Dr. Schaefer has pointed out that the presence of sulphur dioxide in the air may be the cause of respiratory diseases, yet it is fortunate that it also exercises a disinfectant

action as well. A more serious cause of disease in large cities is street dust. This will not be done away with until the automobile has replaced the horse. Until that occurs the objectionable sulphur dioxide does serve a good purpose.

* * *

Chemical works, as a rule, are not operated by small concerns. Any large corporation, especially if it has acquired the pseudonym of a "trust," unfortunately is looked upon as fair game for a species of blackmail. Especially is this so where there is a semblance of truth beneath the claims. In rural communities, where factories are usually located, the farmer with half a case, if he be not first worn out or financially embarrassed by the familiar repeated delays in securing a trial, will obtain a verdict against such an organization as long as the present sociological and political ideas obtain in those communities, or until certain abuses of the centralization of capital are remedied. And the "good trust" suffers with the "bad trust" as a result. To obviate injustice, Prof. Baskerville has suggested, perhaps not for the first time, that such suits, dependent upon technical knowledge, be settled by a commission of experts, properly appointed, which shall first determine, if damage has been done, and then the amount which should be paid in compensation. In this connection it may be said that there is neither uniformity nor definiteness of statement in the codes of our several states in regard to the contamination of the air or of the pollution of our streams. When a plant in New Jersey may generate gases which are complained of in New York, or when smelter fumes produced in Tennessee affect the vegetation in Georgia, it becomes a federal matter. We are not over-enthusiastic on the rapid growth of the paternalistic policy of our federal government. But it would appear advisable for the Department of Agriculture to extend its investigations, co-operate with similar departments of the several states, and recommend the enactment of an uniform and definite law. The government officials would, undoubtedly, receive the cordial co-operation on the part of the works' owners. Such at least appears to have been the case in England.

—◆—

The Resistance of Diaphragms.

The resistance of a diaphragm in an electrolytic cell is often spoken of in such a way that the resistivity of the solid material constituting the diaphragm might appear to have something to do with the resistance which the diaphragm offers to the passage of the electric current through the cell. Of course, it is evident that if a diaphragm is to fulfill its purpose, its solid particles must not carry any current, since otherwise the diaphragm would not act as a diaphragm, but as a bipolar electrode. The resistance of the diaphragm is the composite resistance of all the innumerable passageways of the electrolyte through the pores of the diaphragm. All these passages are electrically in parallel. If we had two diaphragms of entirely different materials (perhaps one a conductor, the other a non-conductor), but with absolutely the same geometrical configuration of the porous passageways, the resistance of the two diaphragms would be absolutely the same in the same electrolyte. Only when raising the impressed electromotive force, a difference would become manifest, since at sufficiently high e.m.f. the diaphragm made of a conductor would begin to act as a bipolar electrode.

Albany Meeting of the American Electrochemical Society.

The following preliminary program has been arranged for the meeting to be held in Albany, Troy and Schenectady from April 30 to May 2.

April 30 (Thursday): Meeting at Albany, N. Y. Headquarters and meeting place, Hotel Ten Eyck. Members are advised to secure their hotel accommodations in advance.

10:30 A. M.—Meeting for reading and discussion of papers.

2 P. M.—Business meeting, followed by reading and discussion of papers.

8 P. M.—Smoker in the café of the hotel.

May 1 (Friday), Schenectady Day.

10 A. M.—Meeting in the lecture room of the Union University. Experimental demonstrations, illustrated lecture, reading and discussion of papers.

1 P. M.—Lunch at the General Electric Company works.

2 to 6 P. M.—Inspection of the General Electric Company plant.

7:30 P. M.—On returning to Albany, informal dinner together, at Hotel Ten Eyck.

May 2 (Saturday), Troy Day.

9:30 A. M.—Meeting for reading and discussion of papers at Rensselaer Polytechnic Institute.

1 P. M.—Lunch at the Rensselaer Inn.

2 P. M.—Visits to points of interest in and around Troy. Trolley ride to Saratoga. End of meeting.

The following papers have been promised, and others will probably be secured in time to place on the printed program of the meeting:

"Corrosion of Iron from the Electrochemical Standpoint," presidential address, C. F. Burgess.

"The Electrochemistry of Light," by Wilder D. Bancroft.

"Conduction in Electrolytes," L. Kahlenberg.

"Mercury Cathodes in Nitric Acid Solutions," J. A. Wilkinson.

"Copper Anodes in Chloride Solutions," Paul Dyshman.

"The Potential of the Nickel Electrode," E. P. Schoch.

"Solubility Determinations in Aqueous Alcoholic Solutions," A. Seidell.

"Industrial Applications of Aluminium," E. Blough.

"Power for Electrochemical Industries," J. Meyer.

"Electrical Conductivity of Graphite," W. Acheson Smith.

"Distillation of Turpentine in an Electric Furnace," F. S. Snyder.

"Mathematics of the Induction Furnace," E. F. Roeber.

"The Synthesis of Hydrocyanic Acid in the Electric Furnace," R. S. Hutton.

Besides the above, papers are promised from the following, but titles not yet to hand: Prof. Charles E. Munroe, Prof. G. A. Hulett, Prof. H. T. Barnes and Mr. A. D. Little.

Papers are, also, probable from F. L. Shinn, J. E. Mills, G. B. Frankforter, Dr. Weedon, Dr. Lindsay and C. A. Doremus.

The Iron and Steel Market.

The total tonnage of new orders for steel products placed during March showed little, if any, improvement over February. Tin plate business has continued to show a steady improvement, permitting more mills to be started, so that the industry is now running very close to full capacity, the present production rate being between 80 and 90 per cent. of the average rate during February and March of last year. Sheets have shown a further, though slight, improvement, the mills now running between 40 and 50 per cent., against 30 and 100 per cent. a year ago. The wire mills also are doing better, and are running to 75 per cent. of capacity. The branches mentioned comprise the most active in the steel trade; others are less active, or more inactive. The structural, plate, rail and merchant mills are running in smaller proportions, in substantially the order

given. The most active lines are those of smaller total tonnage, tin plate, for instance, comprising but about 5 per cent. of our total steel tonnage in a normal year.

The current furnace reports would indicate that the industry is producing at substantially one-half the rate of last October, when the highest point in activity had been reached. In October pig iron production was at the rate of 28,000,000 tons a year, the furnaces of steel interests producing at the rate of 18,000,000 tons and the merchant furnaces (including the charcoal furnaces) at the rate of 10,000,000 tons. The furnace reports indicate that at present the steel works are producing at the rate of 9,000,000 tons a year, and the outside furnaces at the rate of very close to 5,000,000 tons, a total of 14,000,000 tons. Earlier in this depression stocks were accumulating in merchant furnace yards, but at present there do not seem to be further accumulations, although no material reduction in stocks is occurring. A few of the steel works accumulated some stocks toward the close of the year, but at present there is no direct evidence that any stocks are being accumulated by them.

While, as noted, the current blast furnace statistics seem to show that production of pig iron is at a rate substantially one-half that of last October, and no additional accumulation of stocks is apparent, a review of the conditions in finished steel lines, giving each its due weight according to the tonnage produced in normal times, falls quite short of showing that the production of finished steel is one-half the October rate. We feel sure that a discrepancy is recognizable between the different lines of evidence, but we are unable to explain it.

Developments during March do not indicate any material change for the better in productive activity in April. It is true that in some lines decidedly more business has been placed, but it is doubtful if the average of all lines shows an increase in new business, while, on the other hand, shipments are decreasing, or have entirely stopped, on some old business. The steel car industry is an important case in point. During January and February the consumption of shapes and plates by the leading steel car plants tapered off substantially to the vanishing points. At present the only activity at these plants is in the finishing up of some passenger car orders, which do not involve steel tonnage in proportion to the labor involved or the ultimate cost of the cars.

PRICE MAINTENANCE.

On March 19 the general advisory committee in the steel trade, the various sub-committees, and some representative steel manufacturers met in the Steel Corporation's offices, at 71 Broadway, and took the action which had been fully expected in the trade, refusing to recommend any reductions in prices. The present level of finished steel prices is substantially that which was obtained in 1907, the year of greatest activity the trade has ever seen. The price maintenance policy finds fewer critics now than it did earlier in this movement, but purely for the reason that many who formerly believed that prices should be reduced in recognition of the fundamental change in conditions, now assert that the time in which price reductions could have been expected to act as a stimulus is past; in other words, that the opportunity has been lost, and that the whole producing and consuming industry has been notified, and convinced, that a long wait is necessary before the work of rehabilitation can be undertaken with any hope of success.

In sharp contrast with the situation in finished steel, the pig iron market has suffered a great decline, prices being now wholly out of line. Instead of being eager, as it usually is, to make comparisons between prices of material in the different stages of manufacture, the trade has become entirely callous to the lessons which such comparisons would present, thus recognizing that the price situation has become wholly an artificial one. It cannot be discerned, however, that any important demand is accumulating against the possible removal of this artificiality, and it would appear that the failure of such demand to accumulate is one of the chief reasons for the maintenance of the artificial alignment of prices.

PIG IRON.

A decline in pig iron in the Central West has occurred since last report of about 50 cents a ton. In the South and in the Chicago district declines of about the same amount have occurred, while the eastern Pennsylvania furnaces have maintained their former prices fairly well. Virginia furnaces are cutting prices severely for delivery in Eastern territory, and the Eastern furnaces may have to yield.

Very little iron is being sold, and then in nearly all cases only for very early delivery. There is no prospect of increased production, so far as present sales go, but rather the reverse. Single carloads of Bessemer have sold at \$16.75, valley. Basic is nominally \$16, valley. No. 2 foundry has sold in round lots at \$15.50, valley, while carload lots have brought close to \$16. Forge is about \$15, valley. The Southern market has touched \$12, Birmingham, on desirable orders, small lots going at \$12.50 to \$13.

STEEL.

The agreed price of the large mills on billets remains \$28 f. o. b. Pittsburgh. Scarcely any business has been done in the month, but it is understood that through the subterfuge of conversion deals some of the smaller mills would shade the \$28 price by a couple of dollars or so. Effective March 1 a new price system on sheet bars went into effect. The basis had formerly been \$29, f. o. b. Pittsburgh, plus freight to destination. The new system makes a delivered price of \$29.50 at Pittsburgh, McKeesport, Steubenville, Wheeling, Martins Ferry, Youngstown, Niles and such points, and also at the detached points, Canton and Buffalo. The first-named points were put on a uniform basis to give the sheet and tin mills located there an equal chance, while Canton and Buffalo were included because they are points of production. To all other points, such as Clarksburg, Parkersburg, etc., the price remains \$29, Pittsburgh, plus freight. The Carnegie Steel Company is making shipments at the rate of 16,000 to 17,000 tons of sheet bars monthly on the export business taken late last year, 100,000 tons for the first half of this year. These sheet bars are being rolled chiefly at Duquesne, which is now an open-hearth proposition exclusively, and are the first sheet bars rolled at that plant for several years.

FINISHED MATERIAL.

No rail business of consequence was booked during March, the chief development in rails being that the Pennsylvania system's tonnage, 55,000 tons, was not finally placed after all, the mills refusing the orders at the base price on account of the specifications calling for a sound rail and placing the responsibility upon the manufacturers. The matter of whether an advanced price shall be charged is under negotiation.

Occasional structural contracts are being placed, but in general the drafting departments of the fabricating shops have practically nothing to do, and the shops will soon have their tonnage worked out.

The regular prices are being maintained officially, but plates and shapes are being shaded in some cases by \$2 a ton. Regular prices remain as follows:

Beams and channels, 15-inch and under, \$1.70.

Plates, tank quality, \$1.70.

Steel bars, \$1.60, base, half extras.

Wire nails, \$2.05, base.

Sheets, 28 gauge, \$2.50.

Tin plates, 100-lb. cokes, \$3.70.

Iron Reduction in the Electric Furnace.

From the works of the Noble Electric Steel Company, at Heroult-on-the-Pitt, Shasta County, Cal., it is reported that a new experimental furnace for the reduction of iron ore has now been running continuously for several days, turning out 2,400 lb. of pig iron in 24 hours. This furnace was designed by Prof. Dorsey Lyon, of Stanford University, who is on leave

of absence to conduct the experiments at Heroult-on-the-Pitt. The furnace is operated by single-phase current, while the original Heroult furnace was operated by three-phase currents. After the new furnace has been thoroughly tested, the results obtained will be utilized in the design of a furnace of larger size.

American Museum of Safety Devices.

An exposition of two months will be opened on April 13, in New York, under the auspices of the American Museum of Safety Devices and Industrial Hygiene, for showing the best methods of safeguarding workmen and protecting the general public. The exhibits will consist of safety devices, protected machinery in actual operation, models and photographs. During the exposition illustrated lectures, by engineers, will explain industrial conditions and hazardous occupations and the most approved methods of safety.

Believing that many accidents are preventable, and to stimulate further invention, three solid gold medals are offered for the best safety device in the field of transportation, mining, motor vehicles and motor boats; and two prizes of \$100 each, one for the best essay on "The Economic Waste Due to Accidents," and the other on "The Economic Waste Due to Occupational Diseases" are offered.

The chairman of the committee of direction is Mr. C. Kirchhoff, and of the committee of exhibits, Prof. F. R. Hutton. There will be no charge for space. All inquiries and applications for space should be made to Dr. W. H. Tolman, at the Museum, 231 West Thirty-ninth Street, New York City.

Electrochemical Developments in Europe.

While the United States is undoubtedly the country par excellence of industrial electrochemistry, there is also at present a remarkable activity in Europe in electrochemical fields, especially in such districts where cheap water power is available.

The following notes give some interesting information on various recent developments in Europe. They indicate important industrial advances. It was also in Europe that the fixation of atmospheric nitrogen became a commercial success.

The Electrochemische Werke, of Berlin, are in a very flourishing condition, as is indicated by the fact stated in *London Electrical Engineering* that they have just declared a dividend of 9 per cent. They have their chief works in Bitterfeld and Rheinfelden, and also the *Chemische Fabrik Griesheim-Electron* in Frankfurt. They manufacture chlorine, bleaching powder, caustic potash, caustic soda, potassium carbonate, magnesium, calcium carbide, and metallic calcium; they also manufacture oxalic acid, but not by an electrochemical process.

Electrochemical Industries at Lyons. From a recent report we notice that the various electrochemical and electrometallurgical industries in the neighborhood of Lyons have made considerable progress during 1906. It is now intended to procure further water-powers for their exploitation, falls on the slopes of the Pyrenees being utilized, as well as others in the valleys of the Alps. The total amount of power used in the manufacture of chemicals, etc., is stated to have been 100,000 horse-power. For the production of aluminium 35,000 horse-power are used, for that of calcium carbide 25,000, and for that of potassium and sodium chlorate 15,000. The power employed for electric steel furnaces is given as high as 22,000 horse-power (but it is probable that the manufacture of ferro alloys is here included), while the manufacture of soda, chlorine and bleach took 1,000 horse-power, and 2,000 horse-power were employed for various unspecified purposes.

Calcium Cyanamide in Germany.—According to a recent issue of the *London Electrical Review*, a company entitled the *Stickstoffwerke G.m.b.H.*, has been founded in Berlin by the *Cyanid Gesellschaft m.b.H.* (of which the Siemens & Halske

A. G. and the Deutsche Bank are the chief proprietors) in conjunction with the Societa Generale per la Cinamide, of Rome. The object of the new enterprise is to develop the manufacture of calcium cyanamide according to the Frank and Caro process, a factory for the purpose being built in the neighborhood of Spandau. A similar company, to be known as the Ostdeutsche Kalkstickstoffwerke und Chemische Fabriken G.m.b.H. of Berlin, has also been formed to erect and manage a works for the manufacture of calcium cyanamide at Mühlthal near Bromberg, alongside the existing carbide factory of the Brandenburgische Carbidwerk, G.m.b.H., which latter is the chief promoter of the new enterprise.

A New Calcium Carbide Plant in Italy.—In a recent issue of the *Journal de l'Electrolyse* we notice an article by Mr. R. Pitavon on a new plant for the manufacture of calcium carbide erected by Mr. Ch. A. Keller, of Keller-Leleux & Company, in Darfo, in Upper Italy. A cheap water power is available there and there exists at this place already a mill for making iron and tin sheets. At the same place, Mr. Stassano carried out his first work on steel making in the electric furnace. The most interesting feature of the new plant is that it is really divided into two independent plants all the way through, in the hydraulic as well as in the electric installation. There are two turbines, each driving a 5,000-hp, 8,000-volt alternator, the current from each alternator being supplied to four Keller electric furnaces, each of 1,250 horse-power. The furnace hall really contains 10 carbide furnaces, each of 1,250 horse-power, two being held in reserve. It is stated that mechanical appliances have been made use of to the largest extent so as to reduce the manual labor necessary to a minimum. No technical details of the furnaces are given. At the formal opening of the plant, to which many manufacturers had been invited from all parts of Italy, Mr. Keller made some interesting experiments on the production of ferro-alloys, the refining of steel, and the reduction of iron ore in the electric furnace. The plant is stated to be a model plant, and is owned by the Societa Ferriere di Voltri, of which Messrs. Tassara are the general managers. Mr. Keller has been retained by the company as consulting metallurgist, and the company intends to undertake further electrometallurgical operations.

Price of Aluminium.—According to the *London Electrical Review*, "the international aluminium syndicate, which is composed of the Neuhausen Aluminium Industry Company, one English company, two French works, and an American company, has been prolonged as from the beginning of 1908." While the original agreement provided for the allocation of individual spheres of interest, "it is not publicly known whether the renewal of the syndicate carried with it any alterations in these arrangements, although the price of the metal [evidently in Europe only] was reduced to 2s. per kilogram [22 cents per pound] on Jan. 1, 1908. It is now stated, apparently on the authority of consumers in Germany, that customers who really require a larger quantity should be able to obtain it at a still lower price."

"Reactions."

A new trade publication with the suggestive title, *Reactions* has made its appearance. It is published quarterly by the Goldschmidt Thermit Company, of New York, and is "devoted to the science of aluminothermics." The first issue leaves an excellent impression in every respect. It is very well edited. In its mechanical make-up it is exceedingly artistic. Several improvements in the thermit welding process, made during the last year, are discussed and a description of some important repairs made by the thermit process in 1907 is given. There are also articles on applications of thermit in railroad shops, on the evolution of a motor case repair, on thermit for military purposes, on the cost of leakage in compressed-air plants, etc. A suggestive article on the influence of nitrogen on iron and steel deals with the investigation of Braune (our vol. V, p. 51) and suggests the application of titanium thermit. A list of

the representatives of the thermit process all the world over indicates the world-wide importance which the process has already achieved. The publication is sent free of charge to interested parties in this country, Canada, Mexico and Cuba, while for other countries the subscription price is 25 cents per year.

CORRESPONDENCE.

A Modification of the Induction Furnace for Steel Refining.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—It appears from the letter published in your February issue that your correspondent, "M. M. B.," has failed to realize the advantages of the Röchling-Rodenhauser arrangement.

The Colby-Kjellin design provides a melting machine which is unique, in that the material treated therein cannot be contaminated. It is not adapted for steel refining, for very obvious reasons.

The Röchling-Rodenhauser design enables the metallurgist to carry on refining operations by means of slags. The metal is heated in the induction channels, and the central portion of the furnace is used for refining.

The use of the term "electrode" naturally tends to convey the idea of contamination and heavy wear, for nearly all "electrodes" are largely composed of carbon. Further, the use of "electrodes" for melting metal nearly always involves a complicated system of regulation.

The Röchling electrodes, when in use, do not contain any carbon; they are self-regulating, and last for months without showing any sign of wear.

In short, the Colby-Kjellin type provides an ideal furnace for crucible steel and alloys, and the Röchling-Rodenhauser is designed for refining steel for rails, plates, etc.

The writer is intimately acquainted with the practical working of both types of furnace.

NEW YORK CITY.

J. A. H.

Use of Superheated Steam.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—In the February issue of your valuable paper I notice on page 60 in an article by Dr. Franz H. Hirschland on Calculations for Power Plants a statement that "the use of superheated steam for the steam engines would scarcely bring advantages, as the valves of the Corliss engines, which are most extensively used in this country, would have a tendency to bind. With turbines, on the other hand, the use of superheated steam would have to be very seriously considered."

While I agree with the writer that the use of superheated steam is a very important feature in the operation of steam turbines. I can readily prove by numerous examples in practice that there is also a great advantage in superheat for steam engines, including those which have valves of the Corliss type. I can point to a long list of power plants in this country where Corliss engines are being operated with superheated steam, with a fine showing in economy, thereby and without any trouble with the binding of the valves which Mr. Hirschland fears. Some of these plants have been in operation some six or eight years, and in most of them the temperature of the steam ranges from 450 to 500 degrees, and we think it can safely be stated that no difficulty has been experienced with a Corliss engine if used with steam containing 100 degrees superheat, or thereabouts. Possibly the idea that the Corliss engine is not well adapted for superheated steam has been gained from the tendency in Europe to use poppet valve engines where superheat is applied, but it must be borne in mind that this provision is made for cases where the superheat is very high, with a final temperature of over 600 degrees Fahr.

NEW YORK CITY.

E. H. FOSTER,
Vice-president Power Specialty Company.

Metallurgical Calculations.

By J. W. RICHARDS,

Professor of Metallurgy in Lehigh University.

The Metallurgy of Zinc.

At the present time, the metallurgy of zinc is briefly comprehended in the following statements: The chief ore is zinc sulphide, Zn S , infusible at ordinary furnace heats, non-volatile, easily roasted to Zn O ; the roasting is done principally in mechanically stirred furnaces, the ore being in small pieces, because it is non-porous, compact, and roasts slowly; the roasted ore, principally Zn O , is mixed with an excess of carbon as a reducing agent, and heated in closed fire-clay retorts having condensers attached; zinc vapors begin to come off at 1033°C ., and come off rapidly at the working temperature of the charge, say 1200° to 1300° ; the zinc vapor and carbon monoxide pass into the condensers, and as they cool deposit the zinc, some in the form of fine dust (like hoar frost), most of it as liquid drops; the cadmium in the ore and some lead, if present, distil over with the zinc, constituting its chief impurities. Arsenic is sometimes present in the condensed product. Iron does not distil over, but some is absorbed from ladles and moulds in which the liquid zinc may be handled and cast.

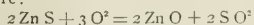
The chief operations with which calculations may be concerned are the roasting, reduction by carbon, condensation of the vapors, possibility of blast-furnace extraction, of electric furnace reduction, electrolytic extraction, electrolytic refining.

ROASTING OF SPHALERITE.

Before roasting, the crude ore is crushed and concentrated. Pure Zn S contains 67 per cent. zinc and 33 per cent. sulphur; its specific gravity is 3.9 and it has fine cleavage, so that it crushes easily, producing much fines or slimes. In the Joplin district, in Missouri, the largest zinc field in America, the ore as mined averages some 4.3 per cent. of zinc, equal to 6.4 per cent. of pure blende, Zn S , and is concentrated by jigging to heads carrying about 60 per cent. of zinc (90 per cent. of Zn S), containing some 70 per cent. of the zinc in the ore, and tails carrying about 1.35 per cent. of zinc (2 per cent. of Zn S), representing 30 per cent. of the zinc in the ore. The concentrates average 5 per cent. of the weight of the ore; concentration ratio 20 to 1. Cost of such crushing and concentration 20 to 40 cents per ton of ore milled. (Ingalls.) The average composition of these concentrates is

Zinc.....	60 per cent. = 90 per cent. Zn S .
Iron.....	2 " = 3 per cent. Fe S .
Silica.....	7 "
Sulphur.....	31 "
	100

Zinc sulphide begins to be oxidized by air at a dull red heat, say, 600°C ., and if the supply of air is kept up the oxidation is rapid, generating a large amount of heat and consequent high temperature:



The question as to how high a temperature would theoretically result if sphalerite were thus burned is an interesting one. Ingalls quotes Hollway as giving 1902°C . We will investigate this point as being of interest and value in connection with practical roasting.

Problem 128.

Pure Zn S is oxidized by air. The heats of formation concerned are

(Zn, S)	= 43,000
(Zn, O)	= 84,000
(S, O^2)	= 69,260

The specific heats of the materials concerned are

Sm to 0°

$$\text{Zn S} = 0.120 + 0.00003 \text{ t}$$

$$\text{Zn O} = 0.1212 + 0.0000315 \text{ t}$$

$$\text{S O}^2 (1 \text{ m}^3) = 0.36 + 0.0003 \text{ t}$$

$$\text{O}^2 \text{ or N}^2 (") = 0.303 + 0.000027 \text{ t}$$

Assuming that the blende is first heated to 600° , to start the roasting, and then the air supply put on, the exposed roasting surface being sufficient for rapid oxidation, and the temperature too high to form SO^2 :

Required:

(1) The theoretical temperature at the roasting surface at starting, if all the oxygen passing is utilized.

(2) The same, when the operation has continued to its maximum temperature.

(3) The same, if three-fourths the oxygen passing is utilized.

(4) The same, if half the oxygen passing is utilized.

(5) The same, if the resulting gases contain only 5 per cent. of SO^2 gas.

Solution:

(1) The reaction gives, thermally:

Decomposition of Zn S	— 43,000 Cal.
Formation of Zn O	+ 84,800 "
" " SO^2	+ 69,260 "

$$\text{Net heat evolution} \quad 111,060 \text{ Cal.}$$

This would be concerned in the oxidation of 97 kg. of Zn S to 81 kg. of Zn O and 64 kg. of SO^2 ($= 22.22 \text{ m}^3$), and requiring $3 \times 16 = 48$ kg. of $\text{O}^2 = 208$ kg. of air (containing 160 kg. $= 127$ cubic meters of N^2).

$$\text{Heat in 97 kg. of Zn S at } 600^\circ = 8,032 \text{ Cal.}$$

$$\text{Total heat in the products} = 119,092 "$$

Mean heat capacity of the products per 1° , from 0° to t° :

$$81 \text{ kg. Zn O} = 9.8172 + 0.002552 \text{ t}$$

$$22.22 \text{ m}^3 \text{ SO}^2 = 8.0000 + 0.006667 \text{ t}$$

$$127 \text{ m}^3 \text{ N}^2 = 38.4810 + 0.003420 \text{ t}$$

$$\text{Sum} = 56.2982 + 0.012647 \text{ t}$$

Therefore, theoretical surface temperature, at starting,

$$119,092$$

$$t = \frac{119,092}{56.2982 + 0.012647 \text{ t}} = 1565^\circ \text{C.} \quad (1)$$

$$56.2982 + 0.012647 \text{ t}$$

(2) When the surface of the oxidizing material has attained its maximum temperature, it is practically at t° , and the products of combustion will contain 111,060 Calories plus the heat in 97 kg. of Zn S at t° . We then have

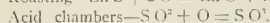
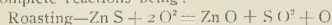
$$111,060 + 11.24 \text{ t} + 0.00291 \text{ t}^2$$

$$t = \frac{111,060 + 11.24 \text{ t} + 0.00291 \text{ t}^2}{56.2982 + 0.012647 \text{ t}} = 1780^\circ. \quad (2)$$

$$56.2982 + 0.012647 \text{ t}$$

It must be emphasized that this is the theoretical maximum under the most favorable conditions as to oxidation and exact air supply, conditions never realized in practice.

(3) The excess of oxygen would be $48 \times \frac{1}{2} = 16$ kg. $= 11.11 \text{ m}^3$. This would be the most favorable possible proportion for making sulphuric acid from the gases, since it would just serve to oxidize the SO^2 to SO^3 in the acid chambers, the complete reactions being:



The 11.11 m^3 of oxygen corresponds to 53.4 m^3 of excess air, whose mean heat capacity is $16.1903 + 0.001443 \text{ t}$. Adding this to the mean heat capacity of the products we have

$$111,060 + 11.24 \text{ t} + 0.00291 \text{ t}^2$$

$$t = \frac{111,060 + 11.24 \text{ t} + 0.00291 \text{ t}^2}{72.4885 + 0.014091 \text{ t}} = 1437^\circ \quad (3)$$

$$72.4885 + 0.014091 \text{ t}$$

(4) This is more nearly the practical conditions, and applying the principles above explained, we have:

$$111,060 + 11.24 \text{ t} + 0.00291 \text{ t}^2$$

$$t = \frac{111,060 + 11.24 \text{ t} + 0.00291 \text{ t}^2}{104.8691 + 0.016077 \text{ t}} = 1027^\circ \quad (4)$$

$$104.8691 + 0.016077 \text{ t}$$

(5) If the gases contain 5 per cent. of SO^2 gas, their total

volume per formula weight of $S O_2$ produced, in kilograms, is
 $22.22 \div 0.05 = 444.4 \text{ m}^3$
 and the volume of excess air they contain is
 $444.4 - 22.2 = 127 = 295.2 \text{ m}^3$
 the heat capacity of this excess air, per average 1° , is
 $80.4456 + 0.007970 t$
 and

$$t = \frac{111,060 + 11.24 t + 0.00291 t^2}{145.7438 + 0.024947 t} = 731^\circ \quad (5)$$

It follows from this analysis and these results, that effective auto-roasting of zinc sulphide is practicable provided that the ore is finely divided, so as to expose large surface, oxidize quickly, and utilize the oxygen of the air efficiently. Without these conditions, auto-roasting is impracticable.

It ought to roast satisfactorily by pot roasting, if the proper conditions as to size of ore, speed of blast, thickness of pot walls, etc., can be found. These conditions are now being investigated by two students in the writer's laboratory.

Problem 129.

Average blende concentrates, containing 90 per cent. ZnS , 3 per cent. FeS , 7 per cent. SiO_2 , are roasted by the use of 30 per cent. of coal, in a furnace with a hearth 135 feet effective length, the unroasted sphalerite remaining being 2.6 per cent. of the roasted material. The iron is roasted to Fe_2O_3 . The coal carries 75 per cent. of carbon, 5 per cent. of hydrogen, 8 per cent. of oxygen, 1 per cent. of sulphur and 11 per cent. of ash. The chimney gases average 2 per cent. of SO_2 , and escape from the furnace at $300^\circ C$. Charge is drawn from the furnace at $1000^\circ C$. Furnace roasts 40,000 pounds per day. Width of furnace, 12 feet; height, 8 feet.

Required:

- (1) The composition of the roasted ore.
- (2) The heat generated by the roasting of 2,000 pounds of the ore.
- (3) The heat generated by the combustion of the fuel.
- (4) The heat in the hot charge as drawn.
- (5) The heat in the chimney gases.
- (6) The heat lost by radiation and conduction.
- (7) The heat loss calculated to pound calories per square foot of outer surface per minute.

Solution:

(1) The 2.6 per cent. of ZnS in the roasted ore is per cent. of it, and not of the raw ore. The simplest method of getting the composition of the roasted ore is to represent by x the quantity of ZnS remain unoxidized per 100 of raw ore. We then have:

$$\begin{aligned} \text{Weight of } ZnS \text{ oxidized, per 100 raw ore} &= 90 - x \\ \text{" " } ZnO \text{ formed} &= (90 - x) \times \frac{81}{97} = 75.2 - 0.835 x \\ \text{" " } Fe_2O_3 \text{ " " } &= 3 \times \frac{160}{176} = 2.7 \\ \text{" " } SiO_2 \text{ remaining} &= 7.0 \\ \text{" " roasted ore} &= 84.9 - 0.835 x \\ \text{" " " " also} &= x \div 0.026 \end{aligned}$$

Therefore

$$84.9 - 0.835 x = x \div 0.026$$

Whence

$$x = 2.2$$

Percentage of the ZnS oxidized

$$\frac{90 - 2.2}{90} = 0.976 = 97.6 \text{ per cent.}$$

Composition and weight of the roasted ore:

ZnS	= 2.2 = 2.6 per cent.
ZnO	= 73.4 = 86.1 " "
Fe_2O_3	= 2.7 = 3.1 " "
SiO_2	= 7.0 = 8.2 " "

Weight 85.3

Zinc contents = 60.0 = 70.3 per cent. (1)

(2) Zinc sulphide oxidized to ZnO

$$2000 \times (0.90 - 0.022) = 1,756 \text{ lbs.}$$

Heat of oxidation of 97 lbs. of ZnS to

$$ZnO \text{ and } SO_2 \text{ (from Prob. 128)} = 111,060 \text{ lb. Cal.}$$

$$\text{Heat of oxidation of 1 lb.} = 1,145 \text{ " "}$$

$$\text{" " " " 1,756 lbs.} = 2,010,620 \text{ " " (2)}$$

(3) Heat of combustion of 1 lb. of fuel to CO_2 and H_2O vapor:

$$C \text{ to } CO_2 \quad 0.75 \times 8100 = 6075 \text{ lb. Cal.}$$

$$\text{Available } H_2 \text{ hydrogen} \quad 0.05 - 0.01 = 0.04$$

H to H_2O condensed

$$0.04 \times 34,500 = 1380 \text{ " "}$$

$$\text{Calorific power to } H_2O \text{ condensed} = 7455 \text{ " "}$$

Water formed

$$0.05 \times 9 = 0.45$$

Latent heat of condensation

$$0.45 \times 606.5 = 273 \text{ " "}$$

$$\text{Calorific power to } H_2O \text{ vapor} = 7182 \text{ " "}$$

$$\text{Coal used per 2000 lbs. of ore} = 600 \text{ lbs.}$$

$$\text{Calorific power} = 2000 \times 7182 = 14,364,000 \text{ lb. Cal. (3)}$$

Total heat generated in the furnace

$$2,010,600 + 14,364,000 = 16,374,600 \text{ " "}$$

Proportion of total generated by the roasting

$$2,010,600 \div 16,374,600 = 0.123 = 12.3 \text{ per cent.}$$

(4) Charge, as drawn, per 2000 lbs. of raw ore:

$$ZnS \quad 44 \text{ lb.}$$

$$ZnO \quad 1468 \text{ "}$$

$$Fe_2O_3 \quad 54 \text{ "}$$

$$SiO_2 \quad 140 \text{ "}$$

$$1706 \text{ "}$$

Heat in this, at $1,000^\circ C$.

$$ZnS \quad 44 \times 0.150 = 6.6$$

$$ZnO \quad 1468 \times 0.153 = 224.6$$

$$Fe_2O_3 \quad 54 \times 0.344 = 18.0$$

$$SiO_2 \quad 140 \times 0.260 = 36.4$$

$$285.6 \times 1000 = 285,600 \text{ lb. Cal. (4)}$$

(5) Sulphur going into the gases:

$$S \text{ from } ZnS = 1756 \times 32/97 = 579.4 \text{ lb.}$$

$$S \text{ " } FeS = 60 \times 32/88 = 21.8 \text{ "}$$

$$S \text{ " coal} = 600 \times 0.01 = 6.0 \text{ "}$$

$$\text{Weight of } S = 607.2 \text{ "}$$

$$\text{" " } O \text{ for } SO_2 = 607.2 \text{ "}$$

$$\text{" " } SO_2 = 1214.4 \text{ "}$$

Volume of SO_2 —

$$(1214.4 \times 16) \div 2.88 = 6,747 \text{ cubic feet.}$$

Volume of chimney gas—

$$6,747 \div 0.02 = 337,350 \text{ " "}$$

Volume of CO_2 in it—

$$(600 \times 0.75 \times 16) \div 1.98 = 3,636 \text{ " "}$$

Volume of H_2O in it—

$$(600 \times 0.45 \times 16) \div 0.81 = 5,333 \text{ " "}$$

Volume of N_2 and excess air = 321,634 " "

Heat in these gases at $300^\circ C$.

$$CO_2 \quad 3,636 \times 0.436 = 1,585 \text{ oz. Cal. per } 1^\circ$$

$$H_2O \quad 5,333 \times 0.385 = 2,057 \text{ " " " "}$$

$$SO_2 \quad 6,747 \times 0.450 = 3,036 \text{ " " " "}$$

$$N_2 \& O_2 \quad 321,634 \times 0.311 = 100,028 \text{ " " " "}$$

$$106,706$$

$$= 6,669 \text{ lb. Cal. per } 1^\circ$$

$$= 2,000,700 \text{ " " " } 300^\circ \quad (5)$$

(6) Summary of heat distribution:

Heat available, per 2,000 lb. ore = 16,374,600 lb. Cal.

Heat in hot ore drawn,	235,600	"	"
" " chimney gases,	2,000,700	"	"
Loss by radiation and conduction,	14,138,300	"	"
	16,374,600	"	"

(7) Approximate periphery of furnace:

$$12 + 12 + 8 + 8 = 40 \text{ feet.}$$

Approximate outer surface, including base:

$$40 \times 135 = 5,400 \text{ sq. feet.}$$

Ore roasted per hour:

$$40,000 \div 24 = 1,667 \text{ lb.}$$

Heat radiated and conducted away per hour:

$$\frac{14,138,300}{2,000} \times 1,667 = 11,781,900 \text{ lb. Cal.}$$

Per square foot outside area, per hour:

$$\frac{11,781,900}{5,400} = 2,182 \text{ lb. Cal.}$$

$$\text{per minute} = 36.4 \text{ " " } \quad (7)$$

The Induction Furnace and Its Use in the Steel Industry.

A very long and full discussion of the electric induction furnace and its application in the steel industry was given in a recent paper of chief engineer VIKTOR ENGELHARDT, read before the Berlin Electrical Society and printed in full in Nos.

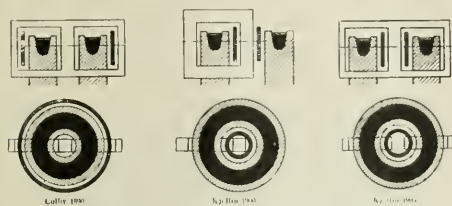


FIG. 1.—INDUCTION FURNACE DESIGNS.

44, 45, 46, 47, of Vol. 28, of *Elektrotechnische Zeitschrift*. We herewith give an abstract of this paper.

Figs. 1 to 5 give diagrams of several typical induction furnace designs.

In the furnace of Colby (1890), in Fig. 1, the primary wind

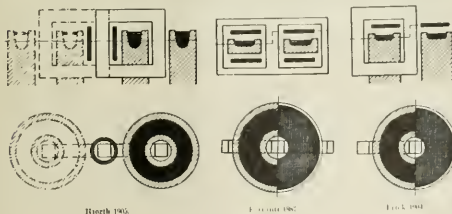


FIG. 2.—INDUCTION FURNACE DESIGNS.

ing surrounds the secondary ring and a double magnetic core is provided. In the furnace of Kjellin (1900), the secondary surrounds the primary and a single magnetic core is used, while in his furnace of 1905 a double magnetic core is used.

In the furnace of Hjorth (1905), in Fig. 2, only the one leg of the iron core, which is surrounded by the primary winding, is

fixed, while the other three legs of the iron core can be attached to the fixed leg either at the right or at the left, so that it is possible to operate two different secondaries in succession

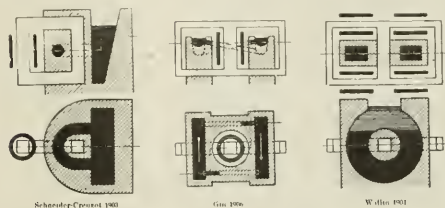


FIG. 3.—INDUCTION FURNACE DESIGNS.

with the same transformer. In the furnace of Ferranti (1887) the primary coils are provided above and below the secondary, and a double magnetic core is used. In the furnace of Frick (1904) the primary is placed above or below the secondary, and a single magnetic core is employed.

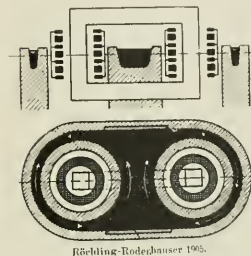


FIG. 4.—COMBINED INDUCTION AND ELECTRODE FURNACE.

others in so far as the metal bath and the slag are electrically in series in the secondary. The secondary ring is vertical and the same current passes in succession through the metal and the slag. Part of the ring is filled with metal, part only with slag.¹

Fig. 4 is a diagram of the Röchling - Rodenhauser furnace, which is a combined induction and electrode furnace, and was described in detail on page 60 of our January issue.

The two designs of Hjorth, of Fig. 5, are other examples of combined induction and electrode furnaces. The upper design in Fig. 5 corresponds to the older design of Hjorth, in Fig. 2, but the secondary ring is not closed; the continuity of the molten metal in it is broken by a refractory wall at one place, connection being made by means of a horse-shoe suspended over this wall, the two ends touching into the slag and serving as electrodes. In the lower diagram of Fig. 5 the horse-shoe again dips

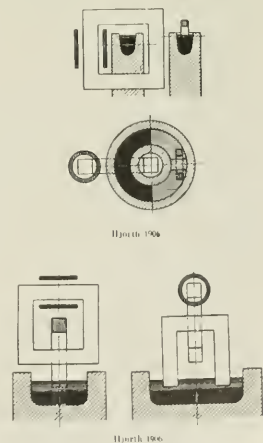


FIG. 5.—COMBINED INDUCTION AND ELECTRODE FURNACE DESIGNS.

(1) A different design, using the same principle, is that of T. F. Snyder, described in our Vol. IV, p. 319.

only into the slag and is electrically in series with the slag and the metal. Horse-shoe, slag and metal form together the secondary. Both these designs are, therefore, combinations of an induction furnace and a Héroult furnace.

The size of the furnace is of great importance for its design and operation. It is, of course, desirable to build a furnace for as large a capacity as possible. But the greater the charge, the lower the ohmic resistance in the secondary and the greater the secondary current and self-inductance. With increasing capacity of the induction furnace, the power factor becomes therefore poorer and poorer, and it is necessary to find means to diminish the stray field. Two remedies have been proposed in this direction. The first is

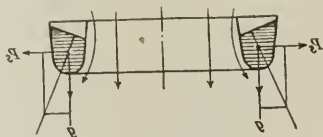


FIG. 6.—INCLINATION OF METAL SURFACE IN INDUCTION FURNACE.

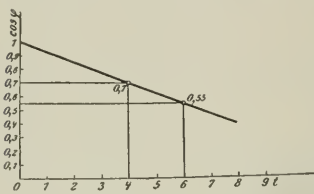


FIG. 7.—INFLUENCE OF QUANTITY OF CHARGE ON POWER FACTOR.

with small furnaces to use ordinary commercial frequencies. The Roechling-Rodenhauser design employs for this purpose a combination of induction furnace and electrode furnace. If the size of their furnace is increased, it is chiefly the middle channel which is increased, so that the cross-section of the other secondary channels, which are heated by induction only, are not increased in the same proportion. The heating of the middle channel is carried out chiefly by the current passing through it between the two opposite electrodes. The power factor is thereby improved. Such furnaces may be operated at 50 periods, even with quite considerable charges, and even for the largest size of furnace it is not necessary to go below a frequency of 25. Mr. Engelhardt states that the employment of an irregular secondary (inclined channels, etc., as in the designs of Gin and Schneider-Creuzot, in Fig. 3) is absolutely unnecessary if the purpose is simply to procure circulation. Whoever has seen an induction furnace in operation knows that it procures sufficient circulation and mixing of its contents, anyhow.

It is a fact that the surface at the top of the bath is not level, but is inclined as indicated in Fig. 6. The reason is that

besides the gravity (g) a pressure P_s acts on the molten bath in a horizontal direction outwards, due to the magnetic stray flux. On account of the inclined position of the surface it seems that the highest layer cools first, circulation is thereby produced which may be described as a rotation around the axle of the secondary ring and in a direction indicated by the arrows in Fig. 6 (that is, in a direction opposite to the direction of

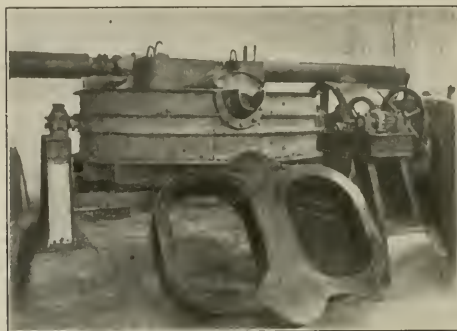


FIG. 9.—ROECHLING-RODENHAUSER FURNACE.

rotation observed in smoke rings). This inclined position of the surface of the bath should not be confounded with Carl Hering's pinch phenomenon, which is something different.

In all induction furnaces it is important to protect the iron core and the primary coil against the radiating heat. In his first furnace designs, Kjellin used both air and water cooling. In later designs, air cooling alone was used. In some constructions the primary coil is copper pipe through which water is passed for cooling. If air cooling is employed it should not

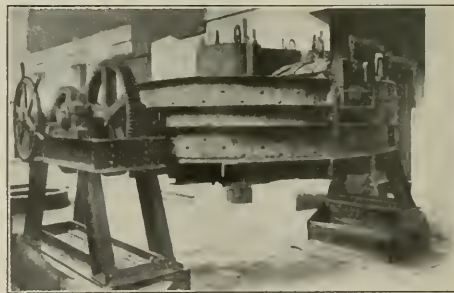


FIG. 10.—ROECHLING-RODENHAUSER FURNACE.

be forgotten that the atmosphere in a steel works always contains more or less conducting particles of metal, ore, oxide, or smoke, which should be kept away from the primary coil. For this purpose filtered wind is generally used for cooling.

It is further advantageous to operate induction furnaces if possible continually since otherwise the linings are destroyed too rapidly due to cracks forming during cooling. If the operation is carried out during the day only, it may be advantageous to leave a small part of the charge during the night in the furnace as a heating resistance to keep the lining warm. But besides the loss of energy, this cannot be considered as very desirable.

Mr. Engelhardt describes various induction furnaces which have been built and gives several illustrations, especially of the large furnace in Völklingen, which was already described and illustrated in our Vol. V, p. 172. As mentioned in that article,

the power for operating this furnace is 750 kilowatts, but from Mr. Engelhardt's article it appears that the charge is not more than 8½ tons. (The statement concerning the charge in our former article should, therefore, be corrected.) Various arrangements for tilting the furnace either by purely mechanical or electric or hydraulic means are described.

Fig. 7 shows how the power factor decreases with increasing charge. This diagram relates to a furnace which can contain a maximum charge of $8\frac{1}{2}$ tons. The abscissae are the charge in tons and the ordinates represent the power factor. These values are, of course, only average values, since the

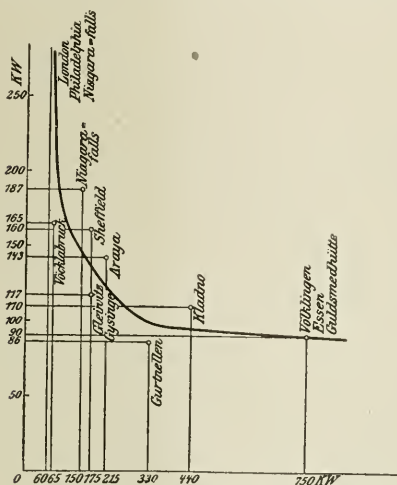


FIG. 11.—RELATION BETWEEN KILOWATTS PER TON AND SIZE OF FURNACE.

phase difference does not only depend on the charge and its cross-section, but also on composition and temperature of the steel and quantity, composition and temperature of the slag above the steel.

Fig. 8 shows how it has been necessary in commercial induction furnace plants to reduce the frequency with increasing size of the furnace. The ordinates give the frequency in periods and the abscissæ give the capacity of the furnace in tons. The names are those of the plants where the furnaces are installed.

During the operation of the furnace, the load remains exceedingly constant, there being almost no variations of the kilowatts. Of course, when in starting a furnace only part of the charge is first introduced and more and more is later added, the load increases gradually, but after all the charge is in the furnace the load remains constant during the melting period proper.

Figs. 9 and 10 show an 80 to 90-kw, 50-period Roehling-Rodenhauser furnace. Its capacity is 500 to 700 kg of steel. It is operated with single-phase current at normal frequency 50 and at 500 volts primary. The pattern shown in the front of Fig. 9 shows the form of the melting channel.

For refining molten open-hearth or converter steel in the electric induction furnace 200 kw-hours or less are required per ton. The figure of 200 kw-hours per ton is based on tests of a Roebling-Rodenhauser furnace of 300 kilowatts. In a pure induction furnace of 750 kilowatts the energy required is 150 kw-hours per ton.

The thermal efficiency of pure induction furnaces in sizes of about 170 kilowatts is something like 50 per cent, with larger units it may be increased up to 80 per cent. The thermal efficiency is higher with the Roechling-Rodenhauser furnace.

Fig. 11 shows how in different commercial plants the energy required per ton of steel decreases with increasing size of the furnace. The abscissae give the capacity of the furnace in kilowatts, while the ordinates give the kilowatts per ton. Thus in the 750-kw furnace in Völklingen 90 kilowatts are required per ton, or, in other words, the furnace is able to treat more than eight tons.

Recovery of Nickel from Oxide and Silicate Ores.

BY WILLIAM KOEHLER.

The present paper is not intended to go into details regarding the well-known smelting and refining processes of copper and nickel from pyrrhotites, but the purpose of the process described below is to handle a different class of ores; namely, the garnierites, nickell-magnesium, silicates, etc., ores which are from a commercial standpoint not readily amenable to smelting methods. This class of ore is abundantly found in New Caledonia, North Carolina and Oregon.

Nickel often forms with magnesia, hydrated silicates such as genthite, garnierite, etc., which are chemically very similar to serpentine and sepiolite. This class of nickel ore has probably originated from the alteration of nickeliferous olivine in peridotites.

Analysis of several minerals from Webster, N. Carolina show approximately the following:

	Dunite,	Talc.	Yellowish green scaly Talc.
Silicon oxide.	41.85 per cent	64.44 per cent	53.91 per cent
Aluminum oxide. . .	trace	0.48 per cent	2.65 per cent
Iron oxide.	7.39 per cent	1.39 per cent	1.46 per cent
Magnesium oxide . . .	49.13 per cent	33.19 per cent	19.31 per cent
Calcium oxide.	0.06 per cent	none	none
Nickel oxide.	0.33 per cent	0.23 per cent	15.91 per cent
Chromite	0.58 per cent	none	none
Water	0.82 per cent	0.34 per cent	6.30 per cent

Sepiolite or meerschaum is a compact mineral whose formula is $H_4Mg_3Si_5O_{10}$ and found in thin layers in serpentine. It often has magnesium replaced by copper and nickel. A sample from Webster, North Carolina, analyzes as follows:

Silicon oxide.....	55.38 per cent
Magnesium oxide.....	15.62 per cent
Nickel oxide.....	17.84 per cent
Iron oxide.....	0.56 per cent
Sp. Gr.....	2.53 per cent
Water.....	10.77 per cent

It is to be seen from this analysis that a very large percentage of magnesium has been replaced by nickel oxide.

Garnierite, which is a species of genthite, and genthite proper occur as amorphous coatings or thin seams in the rocks. These seams or veins sometimes reach a thickness of over an inch. When exposed to the air they lose their color and partially disintegrate.

Genthite and garnierite are both essentially a hydrous silicate of magnesium and nickel. The composition of genthite is expressed by the following formula $2\text{NiO}, 2\text{MgO}, 3\text{SiO}_2, 6\text{H}_2\text{O}$.

Garnierite, an important ore of nickel, found largely in New Caledonia, is of a variable composition, $H_2(Ni.Mg)_3SiO_4 + Aq$ particularly as regards the mutual replacement of nickel and magnesium. Garnierite is often found with a nickel content as high as 45 per cent.

Before going into the hydrometallurgical method of recovering nickel from nickel silicate ores, it may be interesting to know what methods have been tried and what success has been attained. The first method tried near Numea, New Caledonia, consisted in smelting the ores with coke and fluxes in shaft or blast furnaces, to an iron-nickel alloy. This alloy was then exported to Europe to be refined to fine nickel through

oxidizing smelting processes. As it was found impossible by this means to obtain a nickel free from iron and sulphur, the sulphur from the coal and fluxes used contaminating the same, this method of producing an iron-nickel alloy was abandoned. At present the ores are exported to Europe and there they are smelted to a matte with sulphur-bearing materials which is then treated according to well-known methods.

In accordance with the process proposed by Herrenschildt and which is supposed to be in operation at the works of the Maltra Chemical Co., near Rouen, France, New Caledonia ores containing:

Manganese oxide.....	18 per cent
Cobalt oxide.....	3 per cent
Nickel oxide.....	1.25 per cent
Iron oxide.....	30 per cent
Aluminum oxide.....	5 per cent
Magnesium oxide.....	2 per cent
Silicon oxide.....	8 per cent

are treated with a concentrated solution of iron sulphate, through which manganese, cobalt and nickel are brought into solution as sulphates, the iron remaining back as oxide. Out of the solution which is separated and clarified from the residue, cobalt, nickel and a small amount of manganese are precipitated by means of sodium sulphide. It is claimed that through the treatment of this precipitate with ferric chloride, manganese is separated therefrom.

The purified precipitate of cobalt and nickel sulphides is now sulphated through a sulphate roasting, that is, converted into a mixture of cobalt and nickel sulphate. These sulphates are dissolved in hot water and by means of calcium chloride converted into cobalt and nickel chlorides. This solution in order to separate the cobalt from the nickel is divided into two equal parts. Out of one part cobalt and nickel are precipitated as hydroxides by means of lime water, after separation and thorough washing this precipitate suspended in water is treated with chlorine and an air blast in order to convert the cobalt and nickel to a sesquioxide.

This precipitate of sesquioxide is now added to the other portion of cobalt and nickel chloride solution in small proportions, at the same time agitating the mass with a jet of steam, when an equivalent interchange takes place between the cobalt in solution and the nickel precipitate. After all the cobalt has been separated by this means, the nickel chloride solution is removed through filtration and the nickel oxide recovered by precipitation with milk of lime. This process is limited on account of being complicated and it can only be carried on in conjunction with a Le Blanc soda factory.

The hydrometallurgical process which has been proposed for this class of ore consists briefly in chloridizing the mineral completely by any known process then subjecting the same to an oxidation roasting, thereby converting the more unstable chlorides to oxides, regenerating the chlorine, respectively hydrochloric acid, and leaching away the soluble magnesium chloride and then dissolving out the nickel with dilute hydrochloric acid. The solution of nickel chloride thus obtained is to be purified and electrolyzed for metallic nickel and chlorine gas or the nickel can be precipitated as oxide by means of lime water or any other suitable precipitant. Further, nickel may be reclaimed as oxide by the direct calcination of the chloride at a high temperature, the chlorine respectively hydrochloric acid being regenerated. The oxide is readily reducible to the metal by means of heat and coke.

The work accomplished by the late Dr. Hoepfner has proven conclusively the commercial efficiency and practicability of the direct production of metals from their respective chloride solutions together with the liberation for cyclic use or other wise of the combined chlorine.

To emphasize the above—The Brunner Mond Alkali Co., of England, produced by the above method, under the Hoepfner

patents during the period of Nov. 1905 to Oct. 1, 1906, 2,503,382 lbs. of zinc and 8,300,000 lbs. of bleach.

It is also a well-known fact that the International Nickel Co. are producing nickel through the electrolysis of nickel chloride solutions and reclaiming the chlorine for further use.

From the foregoing it will be noticed that the proposed improvements resolve themselves into a chloridizing and leaching problem. The chloridization is readily effected through salt roasting, oxidation by means of ferric chloride, cupric chloride and the like reagents or directly with hydrochloric acid.

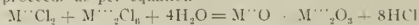
The writer, according to patent 824,663 and others pending, prefers using hydrochloric acid, for the reason that no foreign substances, which have a tendency to load the lixiviant with undesirable salts, are introduced, this being the case if chlorination be effected through salt and sulphuric acid, salt roasting, oxidation with ferric chloride or treatment with bleach in the presence of an acid. After thorough chloridization the product is treated according to U. S. patent 824,139.

This patent has for its object the treatment of ores, mattes, concentrates and other metallurgical products preparatory to leaching. The object of the invention being to so prepare the materials that the leaching may be effected economically and with the production of a comparatively pure metal bearing solution, part or all of the chlorine combined with the base metals of the ore being recovered as chlorine or hydrochloric acid and utilized as desired.

In the application of the above a method will be cited as applied to an ore containing nickel, magnesium, aluminium, iron and gangue. This ore is chloridized and then placed in a rotary kiln, furnace or other suitable vessels for mixing and heating and is there subjected at a suitable temperature to the action of oxygen which may be applied either in a free state as air or in combination with hydrogen as water or steam. The temperature should be below the point of decomposition of the chloride of the metal or metals to be recovered—in the above case nickel—but above the point at which the chlorides of the other metals are decomposed.

The product of decomposition of the base metal chloride will depend on the temperature and duration of treatment. All the chlorine may be expelled, in which case only the oxides will remain or only a portion may be driven off leaving as a residue the corresponding oxychloride.

In case a high temperature and air are used the production of oxide and chlorine liberation proceed as per equation— $M''Cl_2 + M''Cl_6 + 2O_2 = M''O + M''O_3 + 4Cl_2$. In the presence of water, hydrochloric acid is set free and the decomposition proceeds as per equation



If air and moisture are both employed the two reactions occur simultaneously and a mixture of chlorine and hydrochloric acid will be evolved. The chlorine, hydrochloric acid or both so regenerated together with the chlorine derived from the electrolysis is used for the chloridization of further quantities of ore, this making the process cyclic.

The advantages of the improved method are obvious. The temperature required is always below the decomposition point of the metal chloride or chlorides to be recovered, which fact alone represents a decided economy on methods involving the calcination of ores containing tale or clay. The chlorine combined with the base metals such as iron, alumina, magnesia is largely recovered in form available for immediate use. The oxidized residues remaining are only very slowly soluble in the usual lixivants, thus solutions are obtained which are but slightly contaminated by base metal chlorides, and further ores which, owing to their content of clay or other finely divided matter can only be leached with great difficulty are hereby converted into a physical condition which greatly facilitates leaching. Through actual leaching tests without the aid of vacuum or pressure the rate of percolation has been found to exceed one inch per hour.

The above improvements are not alone applicable to alumina,

lime, magnesium, silicate ores, but can be applied commercially successfully to the zinc-lead-silver ores, as also copper ores.

In conclusion I would say that the above process has been tested out in one of the leading electrolytic copper refineries of the United States and has been pronounced by their management perfectly sound metallurgically, the inventors being not disposed to make any extravagant or absurd claims. In a lengthy report they have further recommended that the process justifies the erection of a plant to try out the same on a commercial basis.

Drying Appliances.

By OSKAR NÄGEL, PH. D.

The drying of raw materials and finished products is in a good many cases an important part of a chemical manufacturing

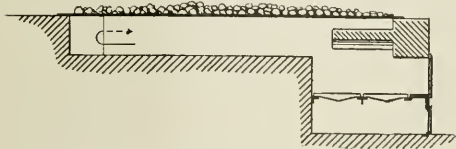


FIG. 1.—SIMPLEST METHOD OF ARTIFICIAL DRYING.

process and should be performed with the greatest possible economy.

To dry a substance means to remove adhering liquid from it, in general, mechanically admixed water. It is always of advantage to mechanically remove (by dripping, filtering, etc.) the largest possible quantity of water, before subjecting the material to the drying process proper.

The water that cannot be mechanically removed has to be removed by evaporation by contact with atmospheric air, which in many cases has to be preheated. Admission of air is especially necessary if the nature of the material to be handled

The simplest way of artificial drying is shown in Fig. 1. The material to be dried is put upon a platform made of iron or clay-plates and heated by the fire gases passing through flues which are provided below the platform. In place of direct firing, frequently steam heating is employed, making use of exhaust steam.

This method of drying is very primitive and should be used only where large quantities of heat, that otherwise would be



FIG. 3.—DRYING CHANNEL.

wasted, are at disposal; the transmission of heat in this apparatus is not at all economical and the material to be dried remains cold on the surface. To overcome the latter disadvantage the material is frequently stirred either by hand or mechanically.

Somewhat more efficient are the so-called drying chambers; in these rooms, which are made of brickwork, wood or insulated iron, the material to be dried is distributed loosely, if it is a solid material, or in vessels or pans if soft or pulverulent. The heat must be sufficient and well adjustable and provision is to be made for the proper escape of vapor or steam by means of a stack or exhauster. Heating is effected by direct firing, hot air or by radiation from a heated surface.

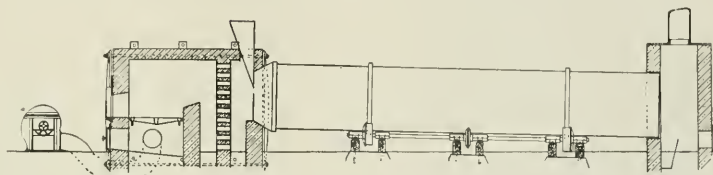


FIG. 4.—ROTARY CYLINDRICAL DRYER FOR DIRECT HEAT.

With such chambers a satisfactory result is obtained only by keeping the temperature in the interior of the chamber far above 100°C , which case is not as frequent as the application of drying temperatures below 100°C .

In the latter case the efficiency of the above arrangement is not at all satisfactory, since no more air is exhausted after the expansion of air in the chamber has reached the degree which corresponds to the chimney draft or the action of the exhauster. The evaporation of water ceases on account of too low a temperature since the air contained in the chamber is soon saturated with steam, so that no more water is absorbed. From this moment on, the heat applied is entirely wasted.

Hence, for preserving the efficiency of the chamber fresh air has to be brought continuously to the chamber; the air is heated up, saturated with steam by contact with the material and removed, so that again fresh air can enter, capable to absorb water. This principle

is to be observed in all drying installations having a temperature below 100°C .

If the air is drawn through the chamber by means of an exhauster, it will pass along the shortest possible way; hence some parts of the material will not be dried at all and in case of a leak cold air will be drawn into the chamber.

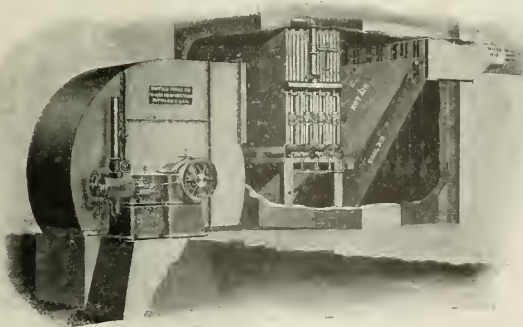


FIG. 2.—FAN SYSTEM OF DRYING.

necessitates the application of a temperature below 100°C at ordinary, atmospheric pressure.

If drying is to be performed at a higher temperature the admission of air may be omitted, but in most cases it is of advantage to admit atmospheric air even at higher temperatures.

A higher efficiency and greater rapidity in drying is obtained if the fresh air is heated before entering the chamber and by pressing (instead of sucking) the air through the apparatus.

Such an installation is shown in Fig. 2. The air which is blown into the chamber, comes in contact—before entering the chamber—with a pipe system heated by steam or hot waste gases and is heated thereby. Dryers of this and similar construction are built by the Buffalo Forge Co., Buffalo, N. Y., and by the B. F. Sturtevant Co., Boston, Mass.

If a material is dried by means of admitting heated air to the material, the operation is continuously changing and becomes more and more unfavorable. It would be of advantage to change the composition of the air corresponding to the progressing dryness of the material. This is done in practice by moving the material gradually from the point of escape of the steam to the point where the hot air enters (principle of counter current). This principle is applied, for instance, in the dry kilns of the American Blower Co.

The simplest plant of this kind is the shaft furnace, which, however, can only be used for fairly hard materials, for the

A dryer which is widely used for drying slag, sand, gypsum, clay, chalk, pyrites, carborundum, graphite, borate of lime, litharge, etc., as built by the Ruggles-Coles Engineering Co., of New York, is shown in Figs 6 and 7. This dryer consists of two shells and operates as follows: The heated air passes through the inner cylinder, shown by dotted lines in Fig. 6,

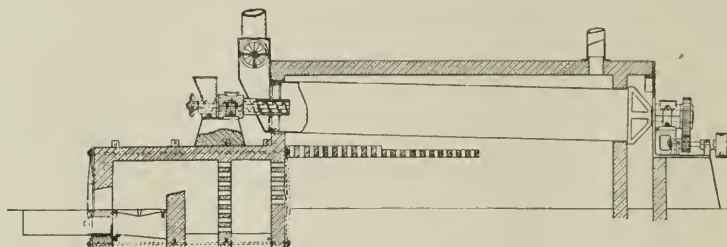


FIG. 5.—ROTARY CYLINDRICAL DRYER FOR INDIRECT HEAT.

and returns between the outer and inner cylinder to the fan. The material to be dried is fed into the machine through a spout in the stationary head, which leads to the bottom of the outer cylinder, where it is taken up by the buckets or carriers and dropped through the current of heated air. It is then caught by the flights on the heated inner cylinder, which by revolving drops it to the outer cylinder to be again carried up.

This operation is repeated until, by the inclination of the machine, the material is carried to and discharged at the rear end. During this operation the material is continually dropping through the current of heated air, which is traveling from the discharge or dry end of the machine, to and out through the fan at the head or wet end. The outer shell is cool at all times and the ex-

haust from the fan is not much above the atmospheric temperature. About 88 per cent of the fuel value is utilized.

In this connection we have to mention also the dryer built by the American Process Co., of New York, which is used for drying chemicals, sand and stock-yard products by direct contact with the products of combustion. This dryer consists of a



FIG. 8.—ROTARY DRYER IN OPERATION.

drying of which the temperature-regulation does not need to be very exact.

The so-called drying channels, which are based upon this principle can be used for almost any kind of material; they are easy to attend and continuous in operation. The use of an exhauster is always to be recommended, since it effects better regulation and makes the plant independent of the weather. Such a channel is shown in Fig. 3. F is the fire place, in M the fire gases are mixed with air and travel through C and the channel A to the flue D and escape through stack E. The cars containing the material to be dried enter through the slide-door S₁ and leave through the slide-door S. For the drying of materials which should not come in contact with the fire gases, this construction can be correspondingly changed.

In continuous operation 7 lbs. of water will be removed by 1 lb. of coal, while when operating for 10 or 12 hours per day 5 or 6 parts of water are removed by 1 part of coal.

The most perfect drying appliance, wherever it can be applied, is the rotary cylinder dryer. A simple dryer of this kind is shown in Fig. 4. Fig. 5 shows same construction adapted for drying of materials, which are not to come in contact with the fire gases. These types are built by the United States Drying Engineering Co.

rotating cylindrical shell, provided on the interior with longitudinal shelves. The wet material and the furnace gases enter the shell, which is set on a gentle slope, at the higher end. This is shown in Fig. 8.



FIG. 7.—CROSS SECTION OF ROTARY DRYER.

The wet material falls to the bottom of the dryer, is caught by a shelf, elevated to almost the highest point of rotation and is then showered through the furnace gases. This cycle of operations is repeated until the material, in a dried condition, is discharged from the lower end of the dryer. The material and furnace gases travel in the same direction.

However, in all drying installations, where the best possible fuel economy is to be effected, the counter-current principle should be applied (Fig. 9). The combustion gases mixed

perforated iron or earthenware trays which contain the material to be dried. After the door of the dryer, which is fitted with an India-rubber joint, has been closed, a high vacuum is created by means of an air pump and exhaust or live-steam or hot water allowed to pass through the heating shelves or pipes. At a very low temperature (about 35° C. or 95° F.), owing to the vacuum, the water starts to evaporate from the material to be dried, the process of drying being finished after a very short time.

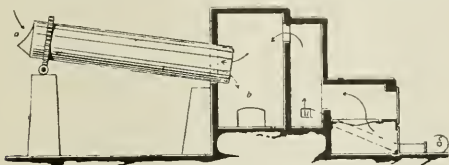


FIG. 9.—COUNTER-CURRENT PRINCIPLE.

with the quantity of air required travel through the interior of the drum. The material is charged at the upper end at *a*, and is discharged at the lower end into chamber *b*, into which also the fire gases are entering on their way to the drum. A fan *c* keeps up the fire and also furnishes the cold air required for mixing.

Finally we have to mention the vacuum drying chamber which was invented by Emil Passburg, of Berlin, and is built by the J. P. Devine Company, Buffalo, N. Y. This vacuum dryer is designed to remove the water rapidly and at low temperature, especially from such materials, which, on account of their sensitiveness to heat, can not be dried by methods

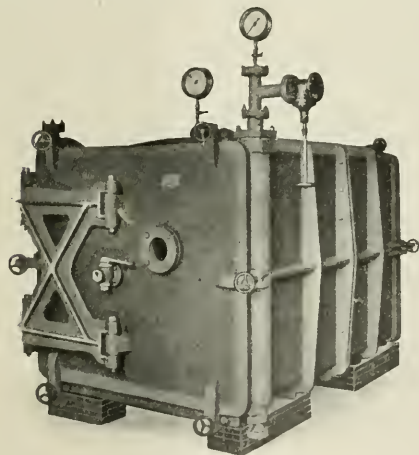


FIG. 10.—VACUUM CHAMBER.

hitherto used, without altering their chemical composition, or from such materials which would have to be subjected to the drying process for a length of time prohibited by practical economy.

This dryer (Fig. 10) consists of a cast iron or wrought iron chamber or cylinder, which is hermetically closed by doors at one or both sides (ends).

The chamber contains a number of closed steam- or heating-shelves or pipes (also for hot water heating), arranged above each other, in which small pipes for the admission and escape of the steam (or hot water) are fitted. The shelves are, as a rule, made strong enough for the test pressure of 75 lbs., the pipes for a still higher pressure.

Upon these shelves are placed iron, copper, galvanized,

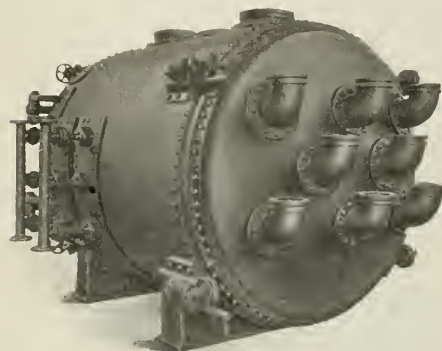


FIG. 11.—SAFETY VACUUM DRYING APPARATUS

Even materials that are difficult to dry, and materials for which it would take days to dry by other methods, or substances which formerly could not be dried at all, are generally dried within a few hours in the vacuum dryer, without affecting in the least the chemical qualities and properties of the substance.

The charging of the chamber is simple and easy, the working very clean and reliable. The temperature can be regulated by means of valves provided in the steam-line. The drying is quite independent of climatic conditions.

By using hot water for heating and by means of an air pump giving a high vacuum, the evaporation of the water contained

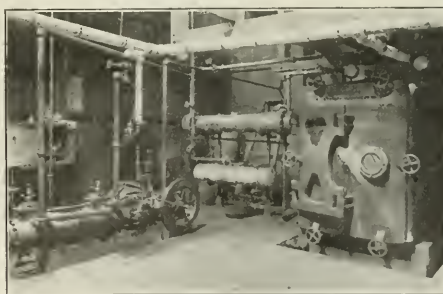


FIG. 12.—VACUUM DRYER IN OPERATION.

in the materials to be dried, takes place at as low a temperature as 17° C. (63° F.).

For drying smokeless powder, fulminate of mercury, gun cotton and other explosives, the construction of the above vacuum dryer is somewhat different, so as to correspond with the special conditions required for drying such substances. The apparatus (Fig. 11), also built by the J. P. Devine Co., of Buffalo, N. Y., is provided with an expansion chamber and other safety devices for the purpose of receiving in case of an explosion, the expanding gases and of reducing thereby their destructive power, as, before exerting any pressure on the

sides of the apparatus, the vacuum in the expansion chamber would have to be destroyed. Then, any excess pressure opens the safety valves of the expansion chamber and the gases can freely escape, thereby preventing destructive explosions. Besides the safety apertures and a very large expansion room, this dryer is also provided with a movable back cover, which is shown in the illustration. In case the inner pressure exceeds the outer pressure (15 lb. to the square inch), this whole back cover will begin to move and open. For this purpose the cover is hung on rollers and held in position by springs.

With this process the time required for drying is reduced to a fraction of that required by the old process; the solvents are more thoroughly eliminated from the powder, the danger of explosion is reduced to a minimum and the solvents are completely recovered.

Vacuum drying apparatus based on a similar principle are built by the F. J. Stokes Machine Co., of Philadelphia, and the Buffalo Foundry & Machine Co.

Fig. 12 shows a vacuum dryer, built by the F. J. Stokes Machine Co., and installed in the works of the Powers-Weightman-Rosengarten Co. in Philadelphia, for drying certain fine chemicals.

No special mechanical appliances are used for drying liquids and gases as in most of these cases the water is removed chemically. So, for instance, turpentine oil is freed from water by treatment with pulverized burnt lime and gases are dried by being led over or through substances having great chemical affinity to water (chloride of calcium, sulphuric acid, etc.). Gases can also be dried physically by cooling.

The Dawn of Chlorine Bleaching.

By CHARLES A. DOREMUS, M. D., PH. D.

Since the obtainment of chlorine and of the hypochlorites was one of the first and is at present one of the most important of all the electrochemical industries, the following citation from a book rarely met with may have some interest. It shows how intimately our domestic tranquility is related to the discovery of scientific facts and their application in the arts. It offers a fine argument in favor of research.

"Manuel Complet du Blanchiment et du Blanchissage. Par M. Julia de Fonetelle. Tome Premier, p. 108: Paris: à la Librairie Encyclopédique de Roret. 1834."

BERTHOLLET BLEACHING.

"When in 1774 Scheele discovered chlorine and studied its properties he announced that it changed vegetable colors to fawn color and ultimately destroyed them so that they did not return. The illustrious Berthollet, guided by these valuable facts, attempted to apply to the arts what had been foreseen by the Swedish chemist. He began therefore, in 1785 et 1786, a series of experiments on chlorine, then known as oxy muriatic acid, and this date may be given as that at which this happy application of this substance to a useful revolution of the art of bleaching was made. At first M. Berthollet had to contend against routine, and prejudice, born enemies of discovery and new methods; but when in 1788 he made known the immense advantages which could be derived by the use of this new agent, both on the side of economy as well as by its rapid action, a few manufacturers decided to try experiments, which though imperfect at first, became, under the direction of Messrs. Walt, Bonjour, the Descroizilles Bros., so improved as to claim the attention of the greater number of manufacturers, who hastened to adopt the Berthollet method of bleaching. A few guided by obstinacy or ignorance, rejected it; but subsequently their own interests compelled its adoption; they ended in comprehending, from their own loss, the immense advantages which this agent offered and which will be better understood from the following extract from the *Mémorial des corps administratifs du département de la Seine inférieure, du ler messidor an XI*.

"Before this great chemist (Berthollet) discovered and published his process for the bleaching of threads and tissues of linen and cotton, the manufacturers of Rouen were obliged to bleach, in the summer, the cotton thread which was to be woven into fabrics in the winter, stuffs which were mixtures of white with blue, or red, etc., and known as *Rouen goods*; they were obliged to wait until the middle of spring to bleach the cloth and knitted goods made in an unbleached state in the middle of autumn. The tying up of capital for so long a time resulted, every four or five years, in the mill-hands having no work during the winter months, a state of affairs which the richer merchants helped to mitigate by a voluntary subscription of 150,000 to 200,000 francs, used to pay for road mending, etc.

"Scarcely had the benefits foreseen by Berthollet begun to be realized under his own eyes, at Paris, than M. Al. de Fontenai commissioned the Descroizilles Brothers to develop the process. Soon after an association of talent and of zeal was formed, Messrs. Fontenai, Sr., and Grandin paying the expenses. It was in 1788 that, after a few obstacles were overcome, the method of Berthollet, perfected by the Descroizilles Bros., gained more and more headway and each year the work was seen to grow at their bleacheries at Lescure-les-Rouen.

"If the city of Rouen is one of those where the wretched period of the revolution was less felt, the discovery of Berthollet was without doubt one of the principal causes why order was maintained in this populous city, while if the workmen had lacked employment, the imagination is appalled at what the agitators might have instigated. The truth of this was so fully recognized that the Mayor and the Chamber of Commerce sent deputations to M. Berthollet, on his passing through the city, to express their debt of gratitude. Many savants, as well as the Prefect of the Department, and the Secretary General, complimented him.

"This homage paid to talent and to the celebrated chemist, whose noble disinterestedness was only equalled by his modesty, was the most charming episode in the life of Count Berthollet. We regret not to have known it when we published an historical notice of this great man, whom we had the honor to have had as master. If one studies the long series of his researches, those relating to philosophical chemistry as well as to industrial chemistry, one finds invariably the savant, who has but one ideal, the progress of science and of the arts; Berthollet did not ask for a patent for this great discovery; he condescended on the contrary to implore the manufacturers to enrich their workshops with this ingenious application and facilitated their acquaintance with it in operating it himself before their own eyes. What an example for many men, even those skilled in the sciences, who barter everything new that comes to their hand and that not always useful!"

Anhydrous Stannic Chloride and Its Use in Silk Dyeing.

We have repeatedly referred in these columns to an interesting and important change which is now going on in the industry of detinning tin scrap (that is, tinned sheet-iron scrap). For quite a number of years the process of electrolytic detinning has reigned supreme, yielding pure tin and pure iron as the end products. But during recent years a number of skillful experimenters have endeavored to substitute detinning with chlorine for the old process of electrolytic detinning. In the process of detinning with chlorine, the tin scrap is brought in contact with chlorine gas under certain conditions and the end products of the process are tetrachloride of tin and iron. The tin tetrachloride is finding a wide and steadily increasing application in the silk industry.

As we noticed already briefly in our last issue, an interesting paper was presented by Mr. ELMER A. SPERRY before the Society of Chemical Industry, discussing the properties and

preparation of anhydrous stannic chloride and its use in silk dyeing. We herewith give a full account of this paper.

Mr. Sperry said that while his paper might be considered in a way as celebrating the third centennial of the "fuming liquor of Libavius" (who discovered it in 1608), yet this

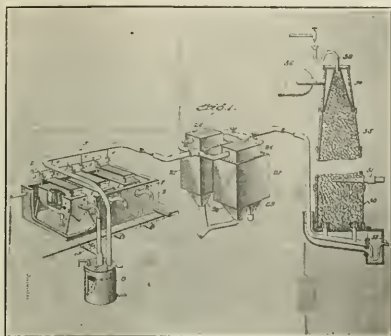


FIG. 1.—DIAGRAM OF PROCESS.

peculiar material has in pure form been known only to very few and was kept heretofore as a chemical curiosity only in very few finely equipped laboratories.

Anhydrous stannic chloride is a liquid, nearly 2.3 times as heavy as water, possessing great fluidity and being most brilliant water-white, far more brilliant than the purest spring water, owing to its high refractory index. This liquid forms two interesting exceptions to the general rule for substances. While it is extremely hygroscopic, really having greater avidity for water than heavy sulphuric acid, yet unlike the acid and other hygroscopic substances it seems impossible to wet it.

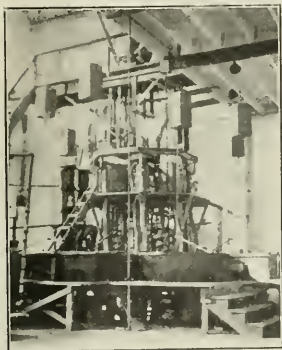


FIG. 2.—STANNIC CHLORIDE PLANT.

As sulphuric acid and other hygroscopic materials absorb moisture, they take up more and more water and finally become, so to speak, "wringing wet," whereas with this material, although its avidity for moisture is evident from the high degree of heat developed upon the addition of moisture or water, yet after the ebullition has ceased, the remaining liquid or essence is found to be as anhydrous and dry as ever and not to have absorbed any of the moisture. The phenomena which actually take place are as follows:

As fast as the moisture is added, stannic chloride hydrate is formed and separates out as a solid, either going off as fume or floating upon the surface as ice or in some instances sinking to the bottom of the vessel, still in the form of a solid, the remaining liquid being as anhydrous as before.

This separated material constitutes the "butter of tin" of commerce, but has not been prepared in this manner except in the laboratory, although this solid was discovered about 160 years after the work of Libavius.

The other interesting matter in which this material departs from ordinary substances is this: When a weak solution of most substances is gradually concentrated or evaporated, it finally reaches a state at which it becomes solid, or crystallizes, at ordinary temperatures, which is usually its form of ultimate density. This is true, for instance, with sugars, in which the syrups are evaporated down to the solid or crystalline form. This is not at all true with the tetrachloride, where the solid form corresponding to a certain amount of water is only intermediate. When the remaining water is removed, the sub-

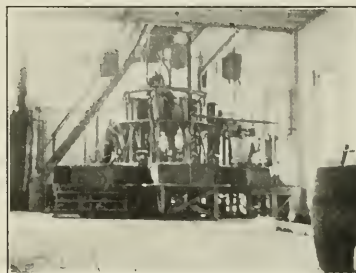


FIG. 3.—STANNIC CHLORIDE PLANT.

stance again becomes a liquid, and when it has reached its ultimate density, it constitutes the true essence and contains nothing but elemental chlorine and tin in molecular proportions. This heavy fuming liquid has been looked upon in the past as of no practical value, never having been used in the arts nor even as an analytical reagent or material. Its price has always been extremely high and at present for chemical purposes commands in the neighborhood of \$100 per gallon. A recent search has proven that this material is to be found in only comparatively few of the more noted laboratories in the country.

At a comparatively recent date a Dutch chemist discovered that cochineal was made to yield a permanent pigment of



FIG. 4.—DISTILLATION PLANT.

great brilliancy in the presence of a dilute stannic chloride solution. This solution was made by dissolving tin in hydrochloric acid, forming stannous chloride, adding additional acid and with an oxidizer correcting the end reaction, thus forming a stannic chloride solution. This discovery was quickly seized upon by the dyeing industry, but the chloride solutions continued to be prepared as used, directly from tin via the muriatic acid route outlined above. The chlorates are usually used as oxidizers, leaving chlorides as an impurity, which is added to the usual impurities encountered in the commercial acids employed. The concentration of these solutions may be

pushed on up to 50° and sometimes 60° Be. for more economical shipping and then again diluted by the dyer before being used.

It has long been known that the mordanting and weighting of the fibre, employing tin chloride solutions, is accomplished only by the stannic chloride present therein, the tetrachloride of tin or essence being the only useful factor in the solution. Mr. Sperry stated that to the impurities in solutions can be definitely traced tendencies to weaken the fibre and render light-sensitive the threads and fibres treated. It is also known that some of the impurities operate to bring about a gradual deterioration in the strength of the material which is sometimes also hastened by exposure to light.

It is clear that all difficulties of this character in silk dyeing are completely solved by the use of chemically-pure anhydrous tin tetrachloride. The delicate fibres and tissues of the silk are thereby subjected to the weighting processes under conditions of entire absence of all foreign and deleterious bodies. Not only is more lustre imparted, but the chemical effect is found to be distributed with absolute uniformity and regularity throughout the entire batch.

Mr. Sperry then discussed his method or preparation of perfectly chemically-pure "essence" or tetrachloride of tin.



FIG. 6.—EXTERIOR VIEW OF FIG. 5.

which is the only active element in the so-called bichloride or the butter of tin.

Fig. 1 shows a diagrammatic view of the plant. Pure or impure tin-bearing material is placed in the receivers 1; chlorine is admitted by the pipe 2 and the product gradually accumulates in the receivers. For economical production of the material, gaseous chlorine in the form ordinarily produced, associated with more or less air and moisture, is employed, the chlorine being absorbed in the receivers.

The air which takes up some bichloride essence and also carries the sublimed hydrate due to the moisture in the gas, is received in pipe 5 and conducted to one or the other of the condensers 26, which serves the two-fold purpose: First to recover nearly all the anhydrous stannic chloride contained in the vapors and air within pipe 5, and secondly, to receive also such stannic chloride hydrate or butter of tin as may also be

contained in these vapors. This latter is drawn off at 29, the former being received by pipe 28 at the bottom of the condenser. The pipe then proceeds to the tower 30 where the vapors rise to the suction of fan 36, in opposition to the downwardly trickling stream of water entering at 32, a solution being readily formed and issuing from pipe 33. A sample of this solution was exhibited, it being perfectly water white; it is a heavy solution, running about 60° Be. About 4 per cent of the total product may be represented by this solution.

One form of the plant for carrying out the process of diagram Fig. 1 is shown in Figs. 2 and 3, where the receivers are seen in the lower part of the figure and are represented by the large rectangular tanks with the condensers above. With this plant about 200 lbs. of bichloride are produced hourly.

One of the peculiar advantages of the product in the form of "essence," constituting as it does anhydrous tetrachloride, is that it possesses not only low specific heat, but a low latent heat, the vapor having a specific gravity of nearly 10, being probably the heaviest steam or vapor known. The raw material may thus be readily treated by distillation as the second step in the process, whereby all the impurities are separated out and left behind, only the chemically pure essence being obtained as a brilliant, sparkling water-white liquid, a substance consisting only of the elements chlorine and tin.

One definite advance attained by the process is that this result is achieved even though extremely impure chlorine and impure tin are employed. Thus cheap sources of both those



FIG. 7.—DISTILLING PLANT.

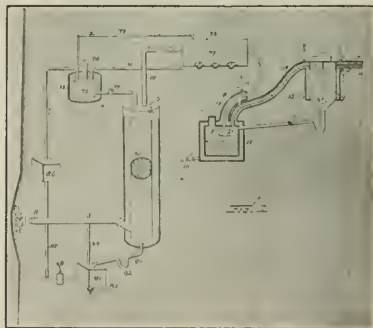


FIG. 8.—CHLORINE DRYING PLANT.

materials are at once rendered available which is in the greatest possible contrast to the usual methods of preparation of the solution, employing as they do only pure and highly refined tin, as any impurity in the tin or substance employed is always found to exist in the solution produced.

Fig. 4 shows one of the plants for the distillation of the product and Fig. 7 illustrates distilling plant having a capacity of 1000 lbs. hourly. In this last figure are to be seen some of the steel drums (in which the essence is shipped) in the lower portion of the figure, to the right. This material has been found to stand for upwards of three years in an ordinary

black iron container without being in the slightest degree contaminated on the one hand and without attacking the material of the drum upon the other.

Figs. 5 and 6 represent plants of larger capacity, the chlorine in Fig. 5 being introduced at 10, the tin-bearing material being supplied from the hopper 16 by the worm 20. The exterior view of two of such plants is seen in Fig. 6, the capacity of these plants being about 500 lbs. of the essence hourly.

Fig. 8 illustrates the chlorine drying plant. The necessity for this is brought about by the fact that by this means chlorine, which is considerably diluted with air, and other gases, may be employed in the process. The chlorine, together with its diluents is passed through the apparatus of Fig. 8, entering at pipe 8, passing upward through the refrigerator 5, where most of the moisture is deposited, running off at pipe 80. The brine or equivalent circulation is shown by pipe 85 and receiver 72. The gas next enters the de-fogging chamber 76, where such moisture as may be carried over mechanically is deposited and then enters the receiver 7, being preferably heated on its way, so as to make it more absorbent. In the vessel 7 is placed anhydrous stannic chloride, i. e., a small part of the product of the plant. As the gases pass through here, the last vestige of moisture is instantly seized upon by the chlorine, the moisture being sublimed out of the chlorine and all the other gases passing. They pass next into condenser 9, where the gaseous chloride is trapped off and returned to the treating vessel 7, the temperature of the jackets in condenser 9 being regulated so as to leave such gaseous stannic chloride in the gases as has been determined based on practice.

The jackets 14 covering the piping are found to be a most effectual method of preventing deposit of hydrate and thus clogging passages, which without this precaution very soon become solidly filled with the hydrate crystals. After months of operation with this jacket, it has been found that the pipes were as free and bright as when first installed, no tendency to clogging nor any deposits whatever being in evidence.

Like the tin tetrachloride thus made, all other tin compounds so derived are of extreme chemical purity, as is easily discernible to the eye. For instance, the butter of tin produced from the "essence" is brilliantly snow white. The solutions are also always water-white.

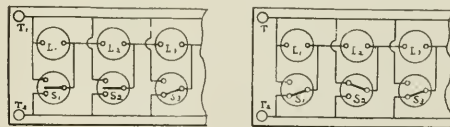
Electrodes.—An article by Prof. W. Muthmann and others, published in a recent issue of *Liebig's Annalen der Chemie*, and noticed in *London Electrical Review*, deals with methods of preparing rare earth metals and their employment. In an appendix to this paper the properties of numerous varieties of electrodes are discussed. The authors state that Acheson graphite is distinguished by its great purity, and its power of resisting the attack of fused salts, chlorine, fluorine and oxygen. The material can easily be machined and can be cut with a knife, sawn, or filed. Gas retort graphite is fairly capable of resisting chemical attack, but is extremely difficult to machine. These varieties of graphite have the advantage of possessing a much lower resistivity at high temperatures. The carbons prepared by Siemens have the unpleasant property of disintegrating rapidly. The carbons made by Lessing, of Nuremberg, do not disintegrate and are very pure. When examined by Schmidt, of Munich, these and other electrodes gave the following electrical resistance per square millimeter $\times$ meter:

	Resistivity in ohms.	
	Cold.	Hot.
Acheson graphite	37.45	14.06
Acheson graphite	21.90	16.56
Siemens carbon	54.73	56.88
Lessing carbon	59.92	49.96
Retort graphite	46.11	47.52
Ceylon graphite	56.84	6.29
Silicon	472.66	183.14
Silicon	509.00	194.01

A Lamp Rheostat.

A recent Faraday Society paper by N. T. M. WILSMORE described a convenient series-parallel lamp resistance for electrochemical work, devised by Prof. J. D. Cormack.

In the figures only three lamps with their connections are shown; but the number of lamps may be increased indefinitely. The lamp sockets L_1, L_2, L_3 , etc., are connected permanently in series with each other and with the terminal T_3 , but, by means of two-way switches, S_1, S_2, S_3 , etc., they may be connected up further in several different ways, so as to produce a wide



LAMP RHEOSTAT.

variation in the total resistance between the terminals T_1 and T_2 . Thus, with three lamps of the same size, six different combinations are possible; two of them are shown in the illustration. The left diagram shows the three lamps in series, the right diagram the three lamps in parallel. If the lamps have a resistance of 100 ohms each, the resistance corresponding to the six steps will be respectively 300, 200, 100, 66.6, 50 and 33.3 ohms. With lamps of different sizes or with a larger number of lamps, the number of possible combinations becomes much greater. A further advantage of the system is that no movement of the switches can cause a short circuit between T_1 and T_2 .

Diaphragms.

By J. R. CROCKER.

In any electrolytic process, where it is necessary to control the products of decomposition in their diffusion, the most vital point to life and efficiency of the cell is the diaphragm. Numerous extended and expensive experiments have been made to find the ideal conditions, or the ideal material, but the field is still open for improvements, and many diaphragms at present in use are in somewhat of an experimental state.

The writer will endeavor to give a concise and brief description of the many attempts which have been made to meet the varied requirements where diaphragms are necessary. It must

be borne in mind that the requirements for a successful diaphragm are varied, and depend largely upon what results are aimed at.

Let us first consider the conditions existing in an ordinary partitioned cell as illustrated in Fig. 1.



FIG. 1.—SIMPLE DIAPHRAGM CELL.

Porous plates, made of earthen ware or other material with pores or spiracles of a more or less microscopical character, are imperfectly permeable.

On this account liquid bodies have been tried, located between two separate partitions (Fig. 2). This works advantageously provided that the liquid which forms the "liquid diaphragm" is kept in a definite and steady position. But this is difficult because unavoidable mechanical shocks, as well as chemical action, always cause an intermixing.

We can make a slight change by substituting between two partitions a quantity of solid material (Fig. 3). This increases the resistance, but the resistance can be varied by varying the thickness of the layer. The principle of the

design must be to get a low resistance and at the same time permit the proper electrolytic action to take place.

A diaphragm of this character was made some years ago. Between two partitions a solution of silicate of soda in water about 18° Beaume was filled in and gelatinized by immersing the diaphragm into an acid or salt solution.

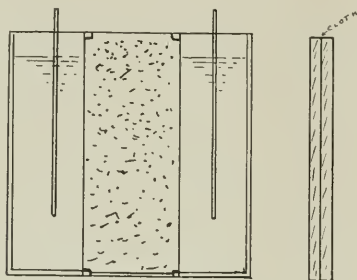
Another method is to use slaked lime of the consistency of mortar where alkaline substances are to be treated electrolytically. In other cases pulverized sulphate of calcium can be used or a fine silica sand or asbestos fiber soaked with acid or salt or a paste made of cornstarch and water, or very porous wood, etc.

A condition which must be guarded against is that there must be no endosmotic or exosmotic action. This is governed generally by the composition of the material comprising the diaphragm.

The more thoroughly gelatinized or the more finely divided the fiber, etc., the more perfect the diaphragm. If asbestos is used in its natural state as a diaphragm in an alkaline solution, it soon becomes a non-conductor. This is probably due to the precipitation through its entire mass of minute par-



FIG. 2.—“LIQUID DIAPHRAGM.”



FIGS. 3 AND 4.—DIAPHRAGM CELL AND ASBESTOS DIAPHRAGM.

ticles of non-conducting material within the pores. To remove the same the asbestos is treated in an acid solution, and afterwards thoroughly pressed, rolled and rinsed with water until the salts are washed out.

Asbestos, if pressed upon asbestos cloth or rolled with it to the required thickness, makes a very suitable diaphragm. (See Fig. 4.) An asbestos material similar to this is now a commercial product.

In the decomposition of metallic salts the efficiency of the operation depends almost entirely upon the condition of the diaphragm and the manner of its use. As an example it may be desired to decompose sodium chloride to produce sodium hydrate and iron chloride. This is done in a diaphragm cell with sodium chloride solution in the compartment containing the carbon cathode and a weak iron chloride solution in the compartment containing the anode of iron. A diaphragm useful for this purpose has been made of a porous earthenware jar or felt saturated and cooked in an aqueous solution

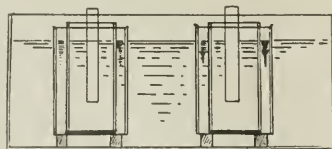


FIG. 5.—MULTI-COMPARTMENT CELL.

of alum, afterwards immersed in caustic soda to be gelatinized.

Diaphragms of this character frequently clog up and offer a greater electrical resistance after long use. The chloride of iron eventually penetrates the diaphragm and meets the sodium hydrate, resulting in the precipitation of a solid mass in the pores.

This intermixing may be overcome by interposing two or even more similar diaphragms. For instance, the arrangement of Fig. 5 may be used, showing special porous anode and cathode cells within a larger tank. In the cathode compartment is placed a solution of sodium chloride and in the anode compartment a weak solution of chloride of iron and in the intermediate compartment sodium chloride. Iron dissolves as chloride at the anode and sodium hydrate is formed at cathode, but the intermingling of the two solutions is prevented by the middle compartment (the large tank in Fig. 5). In case any intermingling should occur it will occur in the middle compartment and not within the pores of the diaphragms.

It is, of course, clear that any such arrangement has two inherent disadvantages. First, the more diaphragms are used the greater the internal resistance of the whole cell. Secondly, while the arrangement may work efficiently for a certain time, after a while it will be necessary to regenerate the solution in the middle compartment.

Diaphragms for such a cell may be made as follows: To a solution of sodium chloride in water a small proportion of bichloride of mercury crystals are added (1 to 2 per cent of the sodium chloride). To this solution when cold is added starch, in the proportion of 3 oz. of starch to 1 qt. of the solution. The mixture is then stirred and heated to the boiling point. The paste is sufficiently thin and hot to pour. It is then poured and allowed to cool when it will be gelatinized.

Another form of diaphragm with a low electrical resistance contains a thin layer of albumin held in place by some such material as paper. To make the albumin of the proper consistency it is dissolved in two parts of water at ordinary temperature, then strained to free from lumps, and then coated (by either dipping or applying with a brush) to one side of the support only. The paper is then heated to a temperature sufficient to coagulate the albumin. The paper in this case is merely used as a support to hold in position the thin film of albumin. The albumin when dried and coagulated has considerable strength and could be supported by the introduction of fibers or threads to hold it in form.

Diaphragms of this kind may be constructed to meet peculiar circumstances. One side of it may be coated with albumin to withstand, say, chlorine, while the other side may be of a material adapted to withstand alkaline solution.

Another form of diaphragm of a low electrical resistance is obtained by introducing into the pores of a sheet or layer of asbestos a mixture of bichromatized gelatine. The latter is made as follows: A quantity of glue is dissolved in a

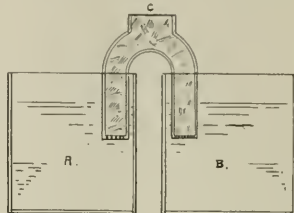


FIG. 6.—“CAPILLARY” DIAPHRAGM.

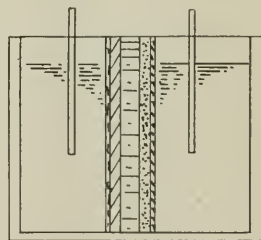


FIG. 7.—DIAPHRAGM WITH NITRATED MEMBRANE.

minimum amount of water and then added to a quantity of bichromate of potash equal to about 2 per cent of the glue. After the ingredients are thoroughly mixed, it can be applied to the asbestos fiber and a layer or sheet can be formed, which is dried and exposed to strong sunlight, or it is passed through a solution of hypo-sulphate of soda. This renders the glue insoluble.

A diaphragm for use in separating highly corrosive liquids, such as chlorine water, may be made as follows: Albumin is dissolved in water in the proportion of six parts of albumin to ten parts of cold water and spread upon asbestos paper, and thus formed into a sheet, which is dried in such a manner as not to coagulate the albumin, and then dipped into a solution of tartrate of antimony, or chloride of tin, or sulphate of aluminium, etc., the result being the formation of an insoluble alumininate of the metal.

The chlorine in acting upon such a diaphragm will attack first the metallic oxide before it attacks the albumin. This prolongs the life of the diaphragm.

A cheap diaphragm, useful in the decomposition of alkaline chlorides, can be made from Portland cement or any such a cement that will set or harden at ordinary temperature. A porous substance, like pumice stone, is mixed with cement in a suitable proportion. Or a soluble substance is mixed with it which will be dissolved out during the setting of the cement

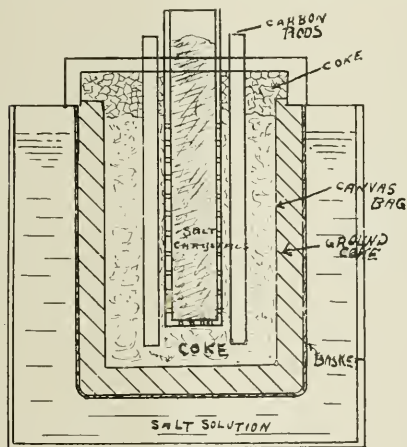


FIG. 8.—DIAPHRAGM CELL FOR SODIUM CHLORIDE ELECTROLYSIS.

or which may be dissolved out after the setting and hardening and so leave the diaphragm in the desired porous condition. The cement, for instance, may be mixed in a concentrated solution of a suitable salt, the cement absorbing the water of the solution and after setting or hardening the salt can be washed out. Such a diaphragm will resist the action of the caustic bodies as well as chlorine. The degree of its porosity can be readily controlled by regulating the mixture.

Another type of diaphragm (and, in fact, a modification of the "liquid diaphragm," Fig. 2) is called the capillary diaphragm composed of an inverted U-tube introduced into the two separate electrolytic compartments. This diaphragm is best understood by referring to the accompanying sketch, Fig. 6.

A and B are the anode and cathode compartments, respectively. C is an inverted-U tube filled with porous material, such as asbestos, powdered glass, sand, etc., or any other non-conducting material, which remains neutral under the electrolytic action. This tube has an opening at the top for filling the tube. The material in the tube is held in place by a perforated bottom in each end.

Another diaphragm is made by nitrating a diaphragm of paper, felt, leather, etc. The nitration may be effected by combining an organic or inorganic material, such as wood or paper pulp, with nitrocellulose and afterward molding to forms, or the same effect may be secured by coating the material with the nitrocellulose. Such a diaphragm is strong and able to withstand pressure.

Fig. 7 shows a diaphragm which is backed up on its anode side with a nitrated membrane, so as to form a cell in the

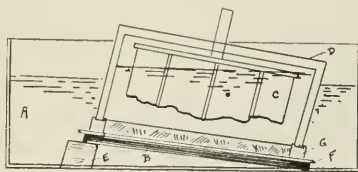


FIG. 9.—EXPERIMENTAL DIAPHRAGM CELL.

center to receive a semi-liquid which will more or less hinder diffusion.

A peculiar cell which has been proposed for sodium chloride electrolysis, and in which powdered anthracite coal is used for the diaphragm, is shown in Fig. 8. Between the insulated wire basket and the canvas bag a filling of "ground coke" is inserted, which is prepared as follows: Anthracite coal is ground to a fine state of subdivision, next a solution is made of silicate of soda or potash of a strength of about 25° or 30° B and about 2 or 3 per cent of caustic soda or potash. The latter is used to prevent the coagulation of the silicic acid by the sulphur or any metallic salts which may be present in the powdered coal and would tend to impair the homogeneity of the diaphragm and weaken it.

A stiff paste is then made of the coal dust and the above. This is placed in the space between canvas bag and wire basket. Then follows within the canvas bag a mash of granulated coke, etc., in which are embedded carbon conductors and a perforated pipe filled with salt crystals. The whole is hermetically sealed by a cover through which the carbon rods and the salt-crystal pipe project. The whole is inserted in a brine tank.

Before starting, a solution of brine is poured on the salt crystals in the tube. The electrical circuit is then closed. On pouring the brine into the anode chamber it comes in contact with the inner surface of the anthracite partition and gelatinizes the silica which it contains, and in time coagulates further in making the diaphragm walls permanent. The chlorine evolved at the anode is carried off from the perforated pipe in the center, while the caustic accumulates in the outer brine compartment.

In cases where horizontal diaphragms have been used for certain reasons, leakage of gases through cracks in the diaphragm has sometimes occurred, resulting in an intermingling of gases with serious results. To prevent this the construction of Fig. 9 has been tried, which for practical work may, of course, be modified.

In an outer vessel, A, the cathodes B are placed, consisting of a number of sheets of wire-cloth held together by a metal ring. C is the anode, consisting of a number of carbon blocks attached to a metal plate. The whole is tilted slightly by the block E, which helps as a support and also facilitates the escape of the gas formed at the cathode. F is an asbestos film resting on the cathode, and G is a ring of earthenware on the upper side of which fine sand, broken stone, etc., is placed. The lower edge of the cover rests on this ring, forming a tight seal. The sand, etc., assists in holding the asbestos material firmly in place upon the cathode so that it cannot be floated or displaced by the gas generated at the cathode.

This layer of comminuted material, combined with the asbestos layer, will effectively prevent the hydrogen gas from entering the anode compartment, thereby eliminating the possibility of the formation of an explosive mixture. It is also essential that the level of the liquor be kept higher within the cell than within the outer tank, thereby preventing the caustic products from entering the anode compartment. This will secure a higher efficiency. By the construction of the cell sufficient space is allowed in the top of the cell for the liberation of the chlorine gas and its subsequent withdrawal.

For many purposes a combination of diaphragm and electrode is useful. One of cheap construction is made as follows: Asbestos is deposited in the form of pulp on wire gauze or on a perforated plate. The fibrous asbestos acts as a porous shield, and the gauze as a permeable electrode. The asbestos may again be covered with Portland cement, plaster of paris, or a mixture of clay and silicate of soda. A diaphragm made of asbestos pulp requires a binding agent consisting of an insoluble silicate made by mixing lime and silicate of soda or potash. The lime and asbestos are deposited on the wire gauze electrode and dried. The electrode and dried pulp are then steeped in a solution of silicate of soda or potash. Calcium silicate is formed which is insoluble.

The binding agent may also consist of an insoluble phosphate, the electrode and dried pulp are steeped in a solution of phosphate of sodium or potassium or ammonium instead of a solution of silicate of soda. Calcium phosphate is formed which is insoluble.

If it is necessary to construct a diaphragm of various forms and to use asbestos fiber in its construction, the following method is quite effective. When the asbestos fiber has been formed as desired, it is subjected to an acid bath, sulphuric or nitric acid, for a short time, and afterwards baked under an intense heat. The heat changes the fiber into the crystalline state, and the acid bath serves to eliminate any metallic oxide which may be in the asbestos and strengthens the same.

In making small diaphragms, the use of asbestos retort cement is recommended, employing a comparatively large proportion of asbestos. In making small diaphragms of this material, an intense pressure should be employed so that the shape leaves the mold or press in a solid and uniform state, free from holes. They are treated with the acid, baked and are then ready for use.

Larger diaphragms, for which the cost of the molds would be prohibitive, can be made from asbestos in sheet form sewed with asbestos thread; blocked up with wooden molds, and binding material forced on the surface, especially around seams, so as to make them air- and water-tight. The diaphragm is then treated with acid and baked. In all such forms, etc., great pressure should be used so as to force the binding material into the pores of the asbestos.

Another form of diaphragm, and an exceedingly cheap one, which is sometimes useful is a slab of soap.

For a diaphragm for use with electrolysis of a molten salt, a filling of granular material which has been subjected to a high temperature and has thus been vitrified, may be employed between two cylindrical steel shells of different size, the smaller shell being inserted in the larger. Both shells have a large number of perforations.

The filling material may be chemically pure magnesia fused in an electric furnace to a vitrified constitution, approximating in appearance clear glass. This is then crushed or granulated to a proper degree of fineness. The particles are preferably of such size as to pass through a twenty-mesh sieve, but not through thirty-mesh. This material is then thoroughly packed between the two shells and the space at the top cemented. The perforations in the shell must not be so large as to allow the material to fall out under the conditions of use. The porosity and resistance of the diaphragm can be varied in accordance with the distance between the surface of the shells.

As mentioned above, cement is used in the manufacture of diaphragms, but when used alone it is not sufficiently porous. This can be overcome by the addition of some porous material or by the addition of non-porous material which is afterwards burned out or dissolved out to leave pores. A mixture may be used of water and cement, and a porous material such as brine, coke, cinders, etc., and a non-porous material, such as sand. The sand may be common sea sand, and the porous material waste cinders reduced to a small size. Suitable proportions are three parts (by volume) of both the cement and porous material, to two parts sea sand. The whole is thoroughly mixed with water to make a pasty mass, and then made into the form of plates and dried. Pores are produced due to the contraction of the cement during drying.

Notes on Electrochemistry and Metallurgy in Great Britain.

(By Our Special Correspondent.)

The Institution of Mining and Metallurgy (London).

At the meeting on the 20th of February last, five papers were read from which the following extracts are taken:

The Alloys of Gold and Tellurium, by T. K. Rose, describes their preparation and properties. The mixtures of Au and Te were made by melting Te or a Te-Au alloy in a clay crucible under charcoal and adding a weighed quantity of Au. Some gravitic separation took place; and the lowest part of the culot contained about one per cent. more Au than the highest. Methods of assaying the mixtures are described. The solidification curve shows a maximum at 452° corresponding to the compound AuTe₂, which consists of gold 43.59 per cent. and tellurium 56.41 per cent.

The main conclusions are: (1) A compound, AuTe₂ or Au₂Te, corresponding in composition to Sylvanite or Calaverite is formed when Au and Te are melted together in certain proportions, M.P. 452° . (2) Two eutectic mixtures are formed corresponding to AuTe and AuTe₂; under the microscope they do not show the characteristic banded eutectic structure, but there are no certain indications that they are true compounds. (3) All alloys of Au and Te are brittle. (4) All those containing less than 60 per cent. of gold melt between 397° and 452° .

A Method of Settling Slimes, as Applied to Their Separation from Solution in Cyanide Treatment, by H. G. Nichols, describes a process which has given remarkable results, both in the completeness of the separation effected and in the small proportion of liquid carried off by the solid matter, which is removed as it reaches the bottom of the tank. This is of inverted pyramidal shape, and connects at the bottom through an 8-inch square aperture with a closed box in which a 10-inch belt is made to travel slowly. The method may be applied in practice in either of two ways. First, as an intermittent process in which the belt discharge of solids would be delivered into a second similar tank where a weak solution or wash water could be sprayed onto the belt to loosen and disintegrate the slime; or a mixer may effect this purpose. After removal of the required proportion of solids the solution would be withdrawn to the original level and a second charge introduced. Secondly, the introduction of a suction filter near to the surface of the liquid in the separator, permits of a continuous process being carried on. The percentage of moisture in the discharge is inversely as the proportion of solids in the separator charge, and the first portions of a discharge from any given separator charge are always better than the succeeding portions, hence if the density of the separator charge is maintained at its initial figure, the moisture in the discharge would be kept at a minimum and the rate of discharge increased. By an automatic periodical cutting off of the suction and application of

small back pressure the filter screen is kept clear from caked slime and clear liquid is continually drawn from a pulp of sp. gr. 1.4. The belt and suction must be so correlated that the solids discharged are proportionate to the liquid sucked out, and the discharge from a pulp of the density stated will uniformly contain about 22.5 per cent. of moisture. If there be two suction pipes with screens they are kept clear by back pressure being applied alternately to each. The continued use of screen suction would not be possible unless the solids were being extracted by the conveyor belt. The procedure in the wash settlers is practically the same. The solids are washed off the belt by precipitated solution and water and the suction withdraws an equal amount of liquid, which is passed through the extractor boxes and returned from the sump. In other processes completeness of washing is dependent on time and capacity of plant, as each instalment of slime is taken separately and washed solution passed through it as long as economically possible, when it must be removed, whether well washed or not, to make room for the next instalment; but in this method continuity is unimpeded and slimes may be washed out with any reasonable quantity of weak solution without affecting the time of treatment—the only factor affected being the capacity of the extractor boxes.

The advantages of this method are: (1) Absence of pumps, carrying machinery and complicated appliances; (2) the separation of sands from slime is not called for, and thus disadvantages attendant on dealing with such classes of material as depend upon close classification are obviated; (3) it is possible to wash to the best advantage and thus reduce the loss by residual moisture; (4) the degree of fineness or uniformity is immaterial; (5) the initial cost is very low, and niceties of adjustment are not requisite; (6) the only limit to the thickness of a charge is the point at which it will not run, and best results are obtained from charges with high percentages of solids; (7) the process may be continuous. The paper is accompanied by diagrams and tables showing the arrangement and the results of working.

Two Deterrents to the Dissolution of Free Gold in the Cyanide Process.

The author, Mr. Duncan Simpson, points out that oil and lime can act as deterrents to the dissolution of free gold by cyanide solution. In one case, on the Witwatersrand, when the sand contained 29 grains of gold per ton no longer amenable to cyanide, laboratory treatment reduced this residuum by further cyaniding to 13 gr. pr. ton when both oil and lime were present. The sample was washed with water; then one part (a) thoroughly washed with ether, and the other (b) with dilute hydrochloric acid. The evaporation of the (a) washings yielded a substance resembling vaseline, and touch-line was found in the (b) washings. Further cyanide treatment reduced (a) to 15-17 gr. per ton, but (b) only 27 gr. per ton. After washing with water (a) was now treated with HCl and (b) with ether: on treatment with KCy (0.25 per cent.) both were reduced to 12-13 gr. per ton. The oil film had resisted removal by working cyanide solution (0.15 to 0.05 per cent.) during the treatment period of six days. Precipitation of an excessive quantity of calcium carbonate was prevented by prolonged aeration, by circulation in the sumps, and steps were taken to prevent leakage of bearing oil into the cyanide works.

A Rapid Method for the Estimation of Arsenic in Ores.

After exhaustive trials of the usual volumetric and gravimetric processes, which were all found unsuited to rapid technical work, Harley E. Hooper arrived at the following method, which is suitable for sulphide or oxidized ores containing upward of 1 per cent. of arsenic. Lead, copper, zinc, iron, manganese or nickel do not interfere. The reactions taking place are (1) $\text{As}_2\text{O}_3 + 4\text{KI} = \text{As}_2\text{O}_5 + 2\text{I}_2 + 2\text{K}_2\text{O}$ and (2) $2\text{Na}_2\text{S}_2\text{O}_3 + \text{I}_2 = 2\text{NaI} + \text{Na}_2\text{S}_2\text{O}_4$. The solutions required are sodium thiosulphate (crystal), 33.1 grm. per litre and sodium hydroxide, 25

per cent. solution. The thiosulphate may be standardized against copper, or against sodium arseniate acidified with HCl. The latter is prepared by treating 0.264 grm. As_2O_3 with 5 c.c. concentrated HNO_3 , evaporating to dryness, heating strongly, taking up with 25 c.c. of NaOH solution, warming, making up to 50 c.c. with water, neutralizing with strong HCl and then adding 25 c.c. more in excess; KI is then added, and the solution titrated until colorless. If addition of starch produces a deep blue coloration standardization must be repeated. For ores containing about 20 per cent. of arsenic, 0.5 grm. is taken, and 10 to 15 c.c. of a fairly strong solution of potassium chlorate in nitric acid added and evaporated to dryness and heated in a 12-oz. tall beaker. After cooling 10 c.c. dilute ammonia are added, the whole boiled, and 25 c.c. of the NaOH solution added; the whole is again boiled, filtered hot and washed with hot water. Filtrate should not exceed 50 c.c. and is neutralized with HCl and titrated as before stated. The proportion of HCl to the bulk of liquid should be one-half or rather more; if less, a reverse action occurs, As_2O_3 being oxidized to As_2O_5 —shown by the color coming and going. Too great an excess of acid prevents solution of the KI, and decomposes the thiosulphate. Titration should be slowly done and care must be given to the finish. Starch is useless in titration, but may be used to confirm the finish. The excess of HCl prevents the thiosulphate discharging the color. To allow for free chlorine in the acid, in exact work a blank titration of water and HCl should be made. If antimony be present in the ore it must be fused with sodium peroxide in a nickel crucible, and the alkaline aqueous extract treated as before. Blank assays with HCl and with KClO_4 took only 0.1 c.c. of thiosulphate. The results quoted go to show that the process is sufficiently exact for technical purposes.

The Indian Mint Assay of Silver Bullion.

F. T. C. Hughes gives a detailed description of the method of assaying silver bullion in the Indian Mints. The author of this paper believes these are the only assay laboratories systematically employing this method. Briefly, the assay pieces (locally termed "musters") are dissolved in nitric acid, the silver is precipitated as AgCl , by hydrochloric acid, and this is dried and weighed. Except in the case of silver of known value all bullion is melted and granulated by pouring into water. This has been found the best way of getting the average value of the pot, as ingots vary in fineness in different parts.

The grain system is used and the "assay pound" fixed at 188.21 gr., corresponding to 25 gr. of silver chloride, which represents 1000 parts of pure silver. The "musters" having been adjusted in weight, each is dissolved in 5 c.c. of nitric acid sp. gr. 1.25, in a special stoppered bottle, the solution being assisted by heat; nitrous gases are expelled by blowing air into the bottle, about 150 c.c. of cold distilled water are added by a nozzle tube, and then 5 c.c. of HCl sp. gr. 1.075, which is a considerable excess; the bottle is now stoppered, allowed to stand a short time, and vigorously shaken until the AgCl aggregates and leaves a clear supernatant liquid; particles adhering to stopper or sides are washed down by a twist of the hand; the stopper is then removed, and the bottle nearly filled with aq. dist. rapidly introduced to stir up the chloride; the stopper is replaced and the chloride settles evenly after standing an hour, when the fluid is syphoned off to within an inch of the chloride; the bottle is refilled with water and the chloride again settles, when the stopper is taken out and the bottle inclined to collect the precipitate on one side, and taken to a trough containing small wedgewood cups or "pots," which stand on white porcelain saucers; the trough is filled with water, and each bottle, closed with the finger, is quickly inverted over its pot and held by a clip—the finger being removed before any chloride reaches it—and is tapped and turned until no chloride remains attached to it, when it is again closed with the finger, removed, and examined for any residual chloride. The pot is removed, on its saucer, from the trough, the saucer examined

and any particles transferred to the pot; after decantation and draining, drying is effected at just below 100°C . for about half an hour, and, when moisture has all disappeared, for 45 minutes at 180°C .; weighings are taken immediately the chloride has cooled, the cake being placed on the *balance pan* and particles adhering to the pot detached with a quill. The use of hot water for washing is more rapid, but less accurate results follow. Any assay where duplicates vary more than 0.4 per mille is rejected. The mean of ten assays of pure silver was 999.94, with a greatest difference from mean of 0.16 per thousand, and, with careful working, the mean of two assays may be relied on to 0.1 per thousand, which compares favorably with volumetric results.

The author then deals with difficulties arising from interfering metals, and allows that when considerable proportions of gold and metals of the platinum group, or of mercury, are present, cupellation is superior. But the process has worked satisfactorily for more than 50 years, and the author's contention that for India—where pure acids are not always easily obtainable—distilled water may, and does, become contamin-

nated, and work has to be conducted with the temperature at 85°F . to 95°F . for many weeks together—it is far preferable to ordinary volumetric methods is not controvertible. It is satisfactory to note that the metric system of weights will probably be adopted for assay work at no very distant date.

Electrochemical Industries and Their Power Supply.

Those electro-chemical and electrometallurgical companies in Great Britain which are not so happily situated as the British Aluminium Company will be, when their Loch Leven scheme is completed, have really no option but to make terms with one or other of the large power companies. Hitherto the Newcastle and the North Wales undertakings have chiefly been successful in securing customers offering such an ideal load. It has, however, recently been announced that the Yorkshire Electric Power Co. have entered into an agreement with the British Carbide Factories, Ltd., who have leased for a number of years, a portion of the supply company's land adjoining the generating station. Buildings are being erected for the large scale manufacture of calcium carbide.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Induction Furnace.—H. Röchling and W. Rodenhauser, 877,739, Jan. 28, 1908. Application filed Sept. 7, 1906.

This refers to some details of the combined induction and electrode furnace which was described in our January issue, page 10. The special object of the present patent is to maintain the slag in the furnace in as hot and thin liquid state as possible. For this purpose some dam-like projections of the

order to impart more heat to the charge in the enlarged hearth *a*, electrodes *e* are provided which are connected with the secondary winding *s*. In the circuit thus formed currents are induced which flow through the hearth *a* between the opposite electrodes *e*. The tap hole of the furnace is located in one of its longitudinal walls. The electrode at that place must, therefore, be broken in the centre, as shown in the drawing. The dam-like projections at the bottom are designated *g* and *h*, and their cross section is shown in the lower diagram. These bottom projections are so formed that the upper edge is uniform with the dividing layer between the molten metal and the slag, as will be seen in the lower diagram. The slit-like opening in the bottom projection *g* has for its object to permit the exit of the molten material enclosed between the bottom projections *g* and *h* when the tap hole is opened.

Induction Furnace.—A. R. Lindblad and O. Stalhane, 880,547, March 3, 1908. Application filed Nov. 5, 1906.

The greatest difficulty met with in the design of an induction furnace is the high magnetic leakage, due to the necessity of keeping the primary and secondary at a safe distance. The inventors state that the leaking lines of force chiefly emanate from the edges of the sheets or lamellae of iron of which the transformer core is composed. Thus, when the transformer core is formed with a rectangular cross section, most of the leaking lines of force emanate from those parts of the core

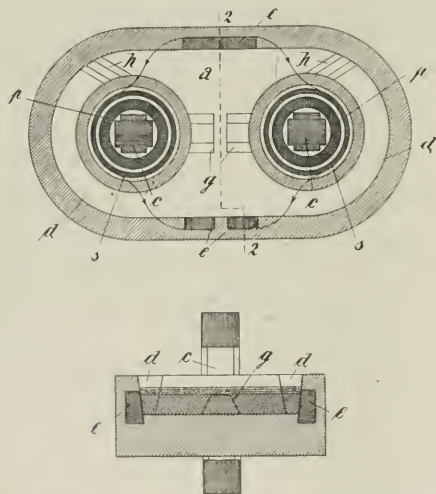


FIG. 1. COMBINED INDUCTION AND ELECTRODE FURNACE.

floor in the smelting space are provided so as to force the current at those places out of the metal and through the slag. The construction is shown in Fig. 1; *c* is the transformer core with the primary windings *p*, while there are two secondaries, one represented by the winding *s* and the other by the charge in the smelting zone. By induction, electric currents are set up in the charge as in the ordinary induction furnace, but in

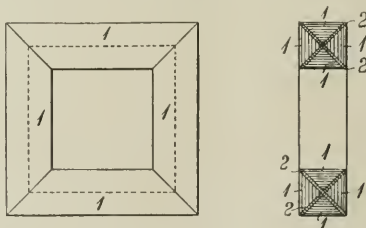


FIG. 2. CONSTRUCTION OF MAGNETIC CORE FOR INDUCTION FURNACE.

which are formed of the edges of the said sheets or lamellae, while only a relatively small number of the leaking lines of force emanate from the other parts of the core; or, in other

words, the leaking lines of force pass more easily along the surfaces of the sheets of iron than across the same. On the basis of this observation they form their transformer core in such a way that its surfaces, as far as possible, are not formed of the edges of the iron sheets which constitute the transformer core, but are instead the iron sheets or lamellae of which the transformer core is formed, so arranged that wherever the leaking lines of force try to escape or emanate from the iron core they are obliged to pass across a number of the said sheets of iron. Fig. 2 gives a front view and a vertical cross section of the transformer core. The iron core is composed of a number of parts or sectors 1 of triangular cross section; these sections are so assembled to form the complete iron core that the iron sheets forming a certain section 1 will be parallel with that side-surface of the complete transformer core which is formed of the same part or section. In order to prevent eddy currents arising within the iron core, the several sections or parts 1 are separated from each other by means of a layer of insulating material 2.

Cooled Electrodes.—F. von Kügelgen and G. O. Seward, 880,743, March 3, 1908. Application filed April 10, 1905. Assigned to Virginia Laboratory Co.

By artificially cooling carbon or graphite electrodes they may be used in electric resistance furnaces without danger of carbonaceous matter being introduced into the charge from the electrode. By water-cooling the carbon electrode the inventors are enabled "to immerse it in the most oxidizing slag or bath, such as molten mixtures or oxides suitable for refining high-carbon metals, without danger of reactions between the electrode and bath and consequent carburization of the product." The "working portion" of the bath (the zone of highest temperature) is remote from the electrodes and in some cases it is advisable to drive the cooling effect so far as to chill the charge in immediate neighborhood of the electrode, so that it forms a conductive and protective coating on the electrode and becomes practically the working electrode.

Electric Furnace Construction.—C. E. Wilson, 881,517, 881,518, 881,519 and 881,520, March 10, 1908. Applications filed Sept. 15, 1906.

In 881,517, the inventor patents the use of comparatively large stationary electrodes in an electric furnace, which may be tilted so as to regulate the heat-generating resistance between the electrodes. He also provides a readily adjustable, as well as removable, "exciting electrode" for use in starting the smelting operation. When the operation is properly started this exciting electrode is withdrawn. By means of electrically actuated controllers, which are automatic in operation, the tilting of the crucible and the movement of the exciting electrode are governed.

In 881,518, a construction of electrodes is described which permits their renewal without interrupting the operation of the furnace. In the base of the furnace is a block of carbon which forms one terminal. The other terminal consists of a plurality of independently controlled and independently adjusted electrodes, each in the form of a battery of pencils of carbon, and each suspended from an independent conductor head. The pencils are each formed in sections and when another battery of pencils becomes shortened to a degree requiring insertion of new sections, the current leading to that battery is shut off without disturbing the current leading to the other batteries.

Patent 881,519 refers to details of the electrode holder. It is circular in form, and is divided into a number of segments each having an opening through which an electrode is carried

down into the furnace. The details of the connections are described.

In 881,520 the sectional construction of amorphous carbon electrodes is described. Each section consists of a plurality of longitudinally extending members, and is provided in opposite ends, respectively, with a dove-tail projection and a dove-tail groove or socket, whereby one section may be readily spliced to another. Bolt openings are provided at the splices or joints, for the insertion of bolts of graphite.

Arc Furnace.—S. D. Spence, 880,338, Feb. 25, 1908. Application filed Dec. 17, 1906.

Details of construction of an electric arc furnace with verti-

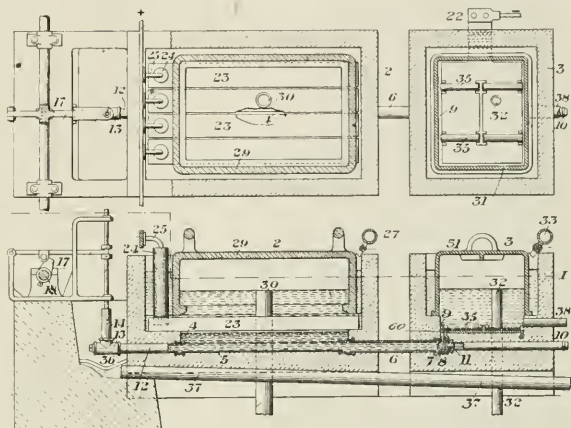


FIG. 3.—MERCURY CATHODE CELL.

cal adjustable inner electrodes, side electrodes and pivotally mounted longitudinal adjustable arms, carrying the side electrodes.

Electrolytic Processes.

Mercury Cathode Cell.—Jasper Whiting, 877,537, Jan. 28. Application filed April 24, 1906.

In this new mercury-cathode cell a new method is employed for removing the sodium amalgam from the electrolytic decomposing cell proper and bringing it to the oxidizing cell for the formation of caustic soda. The characteristic feature is the intermittent action of the cell. During the decomposing period the liquid mercury or amalgam cathode is maintained at a constant level and at a constant and very small distance from the anodes, so that the electric current is practically constant during this period. After electrolysis has progressed for a time the sodium amalgam formed is withdrawn as quickly as possible and the decomposing action ceases. Almost simultaneously a new supply of pure mercury is fed in to the same level as before, this being done as quickly as possible. While for practical purposes a multiple type of cell is preferable, the features of the method will be described here for the sake of simplicity for a single cell. Fig. 3 shows a plan section and a vertical section of the cell, consisting of a decomposing chamber 2, and an oxidizing chamber 3, made of concrete. The bottom of 2 is formed of glass. It slopes from each side downwardly and inwardly to a central longitudinal slot 4, which is provided with straight parallel sides, and embedded in the concrete below it, is a slotted pipe 5, whose slot registers with the slot in the cell bottom. The sodium chloride solution is fed into the decomposing chamber through the supply main 27. 29 is a bell or dome of earthenware which rests upon side ledges of the cell and is sealed by its edges projecting down within the elec-

trolyte. The gas formed during the decomposing period passes off through the pipe 30, which also serves as an overflow for the electrolyte, so as to maintain the latter at a constant level. The oxidizing cell is also provided with a gas collecting bell 31 of iron, while the pipe 32 again serves as a gas outlet and overflow pipe. Water is supplied to the oxidizing cell through 33. In the oxidizing cell the sodium amalgam is decomposed with the aid of particles of chrome iron floating upon the anode and being prevented from being collected together by riffles 35. The electric current is supplied through 25 to the anodes 24 in the decomposing cell, flows through the sodium chloride solution, the mercury or amalgam in the pipes 5 and 6 and then to the iron plate 60 in the decomposing cell and out of it through the connection 22.

The operation is as follows: The valve 14 is closed and a quantity of mercury sufficient to entirely cover the floor of both compartments is fed in. Sodium chloride is then passed into the decomposing chamber through 27 and water through 33 into the oxidizing chamber, the level being determined by the overflow pipes. The current is then turned on and chlorine is set free at the anodes and sodium amalgam is formed at the cathode of the decomposing cell 2. After a predetermined period the cam 17 (at the left of the diagram) acts upon the valve 14 to quickly open it. The mercury contained in the decomposing cell will flow rapidly through the pipe 12 by reason of its great head and its high specific gravity, passing out of 13 (since the valve 14 is now open) and dropping into the well 36. It then flows through the inclined pipe 37 to a pump not shown in the illustrations, which raises it into the oxidizing compartment through pipe 38. The cam 17 is so arranged that as soon as practically all of the mercury in the decomposing chamber is discharged the valve 14 is closed again and mercury free from sodium will rapidly flow from the oxidizing cell through pipes 6 and 5 and will rise through the slot 4 until the equilibrium is re-established. Then electrolysis begins again.

Electrolytic Production of Calcium.—G. O. Seward and F. von Kùgelgen, 880,760, March 3, 1908. Application filed April 24, 1906. Assigned to Virginia Laboratory Co.

The cell shown in Fig. 4 is intended for the electrolytic production of calcium and its alloys and other metals and alloys which are lighter than their molten electrolytes, and whose melting points are either higher or not much lower than the melting points of their electrolytes. A difficulty encountered in the production of such metals is their tendency to burn when they come in contact with air at the temperature at which the electrolysis is conducted. The cell is formed by a vessel A of cast-iron and of circular form. The cathode B projects up centrally through the bottom, while a graphite ring C forms the anode. The electrodes are insulated from the cast-iron vessel by means of the insulating compound *a*. The bottom of the vessel is protected by a chilled layer of the electrolyte; for this purpose the cold water jacket D is provided. The calcium set free at the tapered cathode rises to the top of the bath and

collects within the collecting ring E, which is water-cooled, *b* being the pipes through which the cooling water is supplied. The function of this ring is to confine the separated metal rising from the cathode and isolate it from the gases separated at the anode. By means of the lifting device F the block of calcium *h*, while being formed, is slowly raised above the electrolyte.

Electrolytic Production of Persulphates.—G. Teichner and P. Askenasy, 880,599, March 3, 1908. Application filed Feb. 12, 1906.

In the electrolytic production of persulphates the output gradually diminishes in course of time on account of the formation of Caro acid in the electrolyte. If a reducing agent is added to the persulphate solution containing Caro acid, in proportion to the amount of the latter, the Caro acid is destroyed without any loss of the persulphuric acid. For the production of sodium persulphate, sulphite or bisulphite of sodium, hydrochloric acid and common salt are the most suitable reducing agents. It is preferable to determine once for all the speed of formation of the Caro acid in an electrolyte of given concentration and acidity and then add at regular periods the reducing agent in the proper amount.

Carbon Electrode for Bleaching Apparatus.—Paul Schoop, 880,579, March 3, 1908. Application filed Nov. 26, 1906.

The carbon electrodes used in electrolytic bleaching apparatus must be provided with an unvariable contact. Strips of copper, bronze or brass get readily covered in time with an oxide layer which impairs the originally good contact. This is not the case with silver, platinum or other precious metals, but in this case it is necessary to reduce the amount of metal used as far as possible, in view of the high cost. For this purpose a series of holes are made in the carbon electrodes at a part as remote as possible from the electrolytic liquid and these holes are formed with a screw thread. Conducting strips of silver, platinum or other precious metals which may be very thin, have corresponding holes made in them through which screws are passed, made of carbon and exactly fitting the thread in the carbon electrodes. By tightening up the screws the precious metal is pressed firmly against the electrode and a lasting and unvarying contact is produced.

Magnesium—F. von Kùgelgen and G. O. Seward, 880,480, Feb. 25, 1908. Application filed June 9, 1905. Assigned to Virginia Laboratory Company.

The electrolyte used by the inventors is a solution of magnesium oxide in a fused mixture of magnesium fluoride and one or more alkaline fluorides, or alkaline earth fluorides. A mixture of two parts of magnesium fluoride, one part lithium fluoride and one part calcium fluoride is stated to give good results. Magnesium oxide has a lower decomposition voltage than the fluorides and is, therefore, decomposed in preference of the latter so long as the voltage is kept within certain limits. Instead of magnesium oxide, magnesium oxychloride may be dissolved in the fluorides; in this case both oxygen and chlorine are evolved at the anode during electrolysis. As the magnesium oxide or oxy-chloride is decomposed, it is continually replaced by feeding fresh quantities so as to keep the bath nearly saturated.

Treatment of Complex Cobalt Ores.—E. A. Armstrong, 881,527, March 10, 1908. Application filed May 1, 1906.

Mixed ores of the Teniskaning district, containing silver, cobalt, nickel, arsenic, sulphur and iron, are treated in three steps, as follows: The first step consists in making a solution of cobalt, nickel and iron. The ore is roasted and large portions of the arsenic and sulphur are removed as As_2O_3 and SO_2 , and may be collected. The calcined ore is then smelted with proper fluxes in a cupola or reverberatory furnace, and the resulting matte is bessemerized to remove the excess of iron. The matte is ground and calcined with nitrate or carbonate of soda to further remove the arsenic and sulphur. The calcined prod-

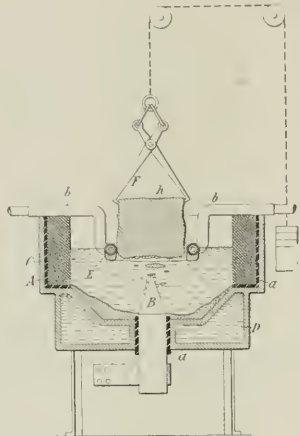


FIG. 4.—ELECTROLYTIC PRODUCTION OF CALCIUM.

net is then mixed with charcoal or retort coal and smelted in a crucible or reverberatory furnace and cast into anodes. These are used in a sulphuric or hydrochloric acid electrolyte and by means of electrolysis the iron, cobalt and nickel are dissolved. The silver, gold and platinum remain back as slimes, and are recovered. The second step is to separate the iron from the iron-cobalt-nickel solution produced in the first step. For this purpose the solution, to which sodium chloride has been added, is electrolyzed between graphite electrodes in a diaphragm cell. The anodic chlorine oxidizes the iron in the solution to the ferric condition. The solution is then drawn off into precipitating tanks and milk of lime or the caustic soda from the cathode compartment of the diaphragm cell are added and the iron and arsenic are precipitated as hydrate and arsenide of iron, the precipitate being removed by filtering or decantation. The third step is to separate the cobalt and nickel from the solution. For this purpose the solution is returned to the diaphragm cell and "the electrolysis is continued until the cobalt is precipitated as oxide of cobalt, which can then be removed by settling or filtering and the nickel can then be precipitated and separated in the same manner. Or, the cobalt and nickel can be simultaneously precipitated as sesquioxides, the caustic soda generated in the cathode compartment being used to assist in the precipitation." The diaphragm cell has graphite anodes at the bottom of the cell, while the cathode is placed near the top. The latter is enclosed within a porous cup, consisting of two perforated hard rubber baskets, one within the other, and the space between the two being filled with asbestos fiber. The solution in the anode compartment is maintained slightly higher than the solution in the cathode compartment, so as to cause a slight flow of the liquid through the diaphragm toward the cathode and prevent the cathodic hydrogen from passing over into the anode compartment.

Mercury-Cathode Cell.—C. F. Carrier, Jr., 881,108, March 10, 1908. Application filed April 25, 1907. Assigned to Elmira Electrochemical Company.

Fig. 5 shows a mercury-cathode cell for the production of caustic and chlorine from sodium chloride. I is a plan view

3-3 of I, and diagram IV is a vertical section on line 4-4 of I. 2 is the anode compartment, and 3 are the two cathode compartments. The chief feature is the methods of producing continuous circulation of the mercury. This is accomplished by means of the centrifugal pump 16, located in the pump well 17 below the general level of the mercury in the decomposing and oxidizing compartments. By means of the pump, pure mercury is drawn from the oxidizing compartments 3 through the conduits 19 (diagrams I and IV) into the pump well 17 in such a manner that the mercury rises within the well and forms therein a deep and effective seal capable under all conditions of preventing the caustic solution from the compartments 3 from passing with the mercury into the anode compartment. The pump 16 discharges through the conduit 20 (diagram III), which extends the entire length of the anode compartment 2. This conduit 20 communicates with the anode compartment above through a slot 21 formed between adjacent edges of glass stripes 22. The conduit 20 is diminished in cross-section in direction of the flow of the mercury so as to provide an even flow of mercury over the entire surface of the anode compartment. By means of the triangular strips 23 of glass or slate the mercury is divided into a series of channels 24 so that in its flow from the center 20 to both sides towards 5 (diagram II), the cross-section becomes smaller and the speed of the flow of amalgam becomes greater as the contents of sodium in it increases. Through the wells 5 the amalgam then passes over into the oxidizing compartments 3, where it gives up the sodium, forming sodium hydroxide. The baffle plates 25 force the amalgam to flow around them and when the amalgam has given up the sodium, the pure mercury flows again into the conduits 19, and so on.

Copper from Ores.—H. K. Hess, 881,580, March 10, 1908.

Application filed Jan. 31, 1907.

Copper ore is pulverized and mixed with clay and small particles of combustible fiber, and formed into briquets, which are burned or baked, so as to remove the sulphur and liberate any volatile matter, while the oxidizable metals are oxidized and the clay which unites the particles is hardened. The fibrous material burns off and leaves the briquets in a very porous condition. Such briquets are assembled within lead frames and used as anodes.

Nitro-Glycerine.—R. Escalles and M. Novak, 880,373, Feb. 25, 1908. Application filed Sep. 5, 1907.

In the manufacture of nitro-glycerine during the first and also the second separation of the nitro-glycerine from waste mixed acids, there is considerable danger due to the slowness of the process of separation. To accelerate the separation an electric current is passed through the solution between platinum wire electrodes, one being at the bottom and the other at the top. The small gas bubbles formed during electrolysis draw the nitro-glycerine suspended in the mixed acids to the surface of the same, from whence it can be easily removed. The nitro-glycerine is completely extracted in a very short time and without danger from the waste acids, which do not lose concentration or become dirty.

Very Thin Sheet Metal.—T. A. Edison, 880,484 and 879,850. Feb. 25, 1908. Applications filed June 29, 1904. (Assigned to Edison Storage Battery Company.)

880,484 refers to the process and 879,850 to the apparatus for producing in a continuous operation ribbons of sheet metal of extreme thinness at low cost. If the thickness of metal sheets is reduced by means of heavy rolls, it is necessary to re-establish the ductility by annealing the material, and eventually to remove the scale of oxide formed during the annealing operation, and the cost becomes very high for very thin sheets. The thinner the sheets to be produced, the cheaper, in comparison, is Mr. Edison's electrolytic method. He deposits the metal upon the smooth outer surface of a revolving drum and detaches the formed deposit readily and continuously from the drum so as

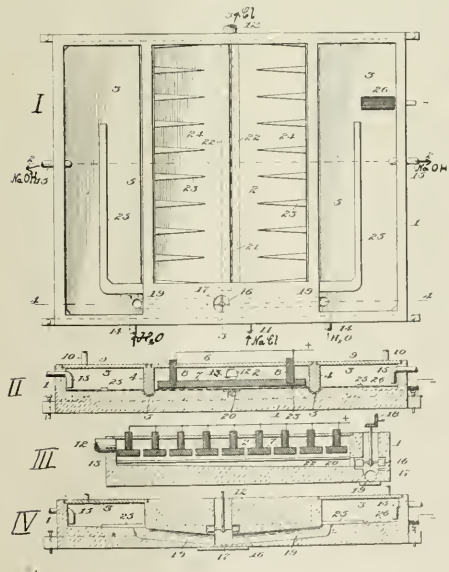


FIG. 5.—MERCURY CATHODE CELL.

the covers and anodes being removed; II is a vertical section on line 2-2 of I. Diagram III is a vertical section on line

to contain a continuous ribbon. This is especially easy if the surface of the drum is made of aluminium or an aluminium alloy, on account of the thin scale of oxide always formed on such a surface, which permits of a clean separation of the deposited metal. An alloy consisting of 95 per cent of copper and 5 per cent of aluminium has proven useful in practice.

Electrolytic Deposits.—H. Schmidt, 880,405, Feb. 15, 1908. Application filed Aug. 7, 1907.

The object is to produce well-adhering electrolytic deposits without pores. For this purpose the article to be plated first receives a coating of a metal or alloy having a melting-point lower than the final electrolytic deposit. After the latter has been applied, and after drying and cleaning the surface, it is subjected to a temperature higher than the melting-point of the intermediate coating, which thereby melts and fills up any pores.

Plating Pipes with Zinc.—G. A. Lutz, 881,810 and 881,811, March 10, 1908. Applications filed April 8, 1907.

The object is to electrodeposit zinc simultaneously on a number of pipes such as are used as conduits for electric conductors. Within a cylindrical tank two concentric sets of anodes are suspended, one near the circumference and the other near the center, while the pipes to be plated are suspended in the space between the two sets of anodes. In 881,811 the anodes in the center are suspended from the same circular cathode plate from which the pipes to be plated are suspended, but, of course, the anodes are insulated from this cathode plate.

Discharges Through Gases.

Sterilizing Apparatus.—E. P. Beckwith, 881,533, March 10, 1908. Application filed Nov. 9, 1905. Assigned to General Electric Company.

The apparatus, which is intended for the sterilization of water and treatment of air in domestic use and in hospitals, consists of three concentric glass tubes, the outer surfaces of which are covered with aluminium foil. Between these surfaces the silent discharges take place which produce the ozone. Water streams into the inner tube, through a construction near its top, and by an injector action air is drawn into the innermost tube from the space between the outer tubes. By means of this air circulation, and by the mixture of air and water, the tubes are effectively cooled. The mixture of air and water, which leaves the innermost tube at the outer end, is thoroughly impregnated with ozone.

Electric Discharges Through Gases.—A. J. Peterson, 880,337 and 880,464, Feb. 25, 1908. Applications filed Aug. 23, 1904.

The gas mixture to be treated by electric discharges is subjected to rapidly moving arcs between opposite electrodes of various forms. For instance, the two electrodes may consist of two metallic conductors embedded in two opposite walls of the furnace (as in the well-known horn-lightning arrester, which is based on the same principle). Special electromagnetic means are provided to move the arc rapidly.

Batteries.

Nickel-Iron Storage Battery.—E. W. Jungner, 880,027, Feb. 25, 1908. Application filed April 4, 1907.

The active nickel electrode is made by mixing thin flakes of nickel with divided crystalline graphite, part at least of which has been previously nickel-plated, and stirring the mixture with a solution of an ammonium salt to which has been added sulphuric acid, to a paste, which is kneaded into the meshes of a network or into perforated plates of pure nickel, or of a nickel alloy provided with a suitable contact device. The electrode thus formed is dried and thereafter drenched in the same solution, and this is done repeatedly in succession, until the mass consists of a conducting skeleton of nickel and graphite particles, while the intervening spaces are filled with nickel-ammonium salt. The electrode is then used as an anode in an alkali solution, whereby the nickel-ammonium salt is changed into electro-active nickel hydrate. The plate thereby becomes

porous, and in order to introduce more active mass into the plate it is washed with water to remove any adhering alkali hydrate, and is then put into an electrolyte of sulphate of nickel, slightly acidulated. In this electrolyte the different constituents of the plate represent a short-circuited couple, whereby more nickel hydrate is formed. By anode electrolysis the lower nickel hydrate is hereafter transformed to a higher hydrate. The iron electrode is treated by discharging it until the greater part of the active mass is oxidized to $\text{Fe}(\text{OH})_2$. The plate is then put into a solution of chloride of iron and ammonium and is connected with an iron plate put into the same bath. The reaction taking place is $2\text{Fe}(\text{OH})_2 + \text{Fe} = 3\text{Fe}(\text{OH})_3$.

Storage Battery.—A. O. Tate, 880,420, 880,421, 880,422, 880,423, 880,424 and 880,425, all of Feb. 25, 1908. Applications filed Dec. 1, 1905; Oct. 29, 1907; July 3, 1907; Oct. 29, 1907; Oct. 29, 1907, and Oct. 29, 1907, respectively.

All these patents refer to mechanical details of a pasted plate of the Brush-Faure type, the special feature of which is that it is a "bi-functional" plate containing both anodes and cathodes. The anodes and cathodes are of strip or ribbon form separated from each other by strips of insulated media, all anodes being connected together to a common conductor at one end and the cathodes similarly connected together at the other end.

Primary Battery.—F. A. Decker, 880,196, 880,367, and 880,368, Feb. 25, 1908. Applications filed March 21, 1904; May 9, 1905, and March 21, 1904, respectively.

These three patents relate to details of construction of the Decker primary battery, which has been repeatedly noticed in these columns, and refer especially to details of electrolyte distribution and drainage apparatus by which the several compartments may be filled and emptied by conduits through a channelled lid or base, and also to other details of construction which render the making of connections and the assembling and dismantling of the battery easy.

Battery Holder.—E. S. Egge, 881,181, March 10, 1908. Application filed Aug. 14, 1907.

On a base plate sockets are permanently located, which receive the set of dry cells. Each cell is provided with a terminal plug of conical shape so as to seat itself in an elastic cone made of wire spirals mounted on the base plate.

Treatment of Battery Elements.—A paper by O. W. Brown and R. R. Sayers printed in the twelfth volume of the *Transactions of the American Electrochemical Society* deals with the treatment of storage battery elements before putting them out of commission. Quite a number of different methods were applied to negatives and positives and the comparison of the results obtained is given. It appears that the preferable method to treat complete battery elements is the one which is described as follows: "Put in the drying rack. After thirty minutes it became steaming hot. It was cooled for ten minutes in distilled water, replaced in the drying rack, and then cooled a second time for ten minutes in distilled water. After drying another hour and cooling for ten minutes as before, the plate was dried two hours, during which time it did not become warm. It was then put in 1,225 sp. gr. sulphuric acid for one hour, removed, and dried for nine days. It remained in excellent condition in every respect."

However, when the application of this method is very inconvenient, as would be the case with large stationary batteries, the following methods applied to negatives and positives should be used. For negatives: "Put into distilled water and allow to stand twelve hours. It was dried fourteen days, after which it had a slightly lighter color and a few more cracks than before. It gained slightly in capacity." For positives: "Placed in distilled water for twelve hours, and was then allowed to dry nine days, at the end of which time it was in very good condition."

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

Electric Furnaces.

New Electric Furnace.—A paper by L. Clere and A. Minet published in the *Comptes Rendus*, Feb. 3, and abstracted in *Lond. Elec. Eng'ing*, Feb. 20, describes an electric furnace in which any temperatures from red heat up to the temperature of the arc may be conveniently obtained. When an arc is surrounded by oxide of calcium or magnesium, or other refractory substance, it may be several centimeters in length without consuming more than ordinary power. Keeping the e.m.f. constant at, say, 60 volts, the length may be varied at pleasure by giving the cavity suitable dimensions and the current a certain strength. The sectional area of the cavity containing the electrodes should vary according to a power of the length, which is a little higher than unity, and the current should vary with a power of the sectional area somewhat less than unity. A magnesia or carbon crucible is introduced into the cavity from below. It is mounted on a rod, which can be raised or lowered into any desired position from outside. The crucible contains from 2 to 40 grams of the substance to be treated, according to its density. The power consumed is one or two kilowatts. The temperature is regulated by bringing the crucible nearer to the arc or further from it. An unusual advantage claimed is that after one electrode has been withdrawn and reinstated, the arc relights without contact.

Production of Artificial Diamonds.—Two interesting articles by Dr. A. E. Tutton have recently appeared in the (*London*) *Times Engineering Supplement* upon "The Diamond and Its Artificial Reproduction." They are abstracted in *Lond. Elec. Eng'ing*, of Feb. 20. The first article deals mainly with the diamond as it is found naturally occurring and its properties. It is premised that the diamond is always produced by the crystallizing of molten carbon under pressure, and it is presumed that the crystallization usually took place within molten iron. The blue clay which forms the pipes in which the diamond is found is not the magma in which the crystallization took place, but the diamonds have been forced up into the clay by volcanic agencies. Recently blocks of one of the original rocks in which crystallization took place were found in blue clay. These blocks consisted of an eclogite containing large quantities of iron, and small diamonds were actually found within them, thus giving the final proof that such was the original mode of origin of the diamond. Although carborundum and metallic tantalum approach the diamond in hardness, they do not exceed it, and the diamond is still the hardest substance that we know. Although diamond is exceedingly hard, it is extremely brittle, and can be readily reduced to a powder by a blow from the hammer. But Sir William Crookes has shown that if it be placed between two hard steel jaws, and an even pressure applied, the jaws can be made to touch each other, the diamond having been embedded into the hard steel as if it were wax. By strongly heating a diamond in an electric arc, it can be converted to graphite. Quite recently Parsons and Swinton have shown that by rapid bombardment by means of cathode rays the diamond can be converted into a graphite coke. The current used was about 48 milliamperes at 11,200 volts, and at a temperature of 1,800 C., the diamond swelled up and became converted into this coke. It was left to electric furnace methods to prove on a laboratory scale that the necessary conditions for the production of crystalline carbon in the form of the diamond are high temperature, high pressure and slow solidification. High temperature, because it is first of all necessary to liquefy the carbon. It has been found when amorphous carbon and graphite are heated to a temperature of 3,000° in the electric arc, in an atmosphere incapable of chemically acting upon the carbon, that they vaporize, without

first liquefying, and on cooling condense to form crystals of graphite. Diamond, on the other hand, is first converted into graphite, and then vaporizes, and on condensation forms graphite. Arsenic behaves in a similar manner, but if heated under pressure, it can be liquefied. The conclusion then is, that if carbon is heated to a sufficiently high temperature at a sufficient pressure, and is allowed to cool under pressure, crystalline carbon in the form of diamond will settle out.

In 1896 Moissan showed that by dissolving sugar carbon (the purest form of amorphous carbon) in molten iron, and plunging it into cold water or mercury, great pressure is produced. When pure iron is cooled it contracts regularly, like any other metal. But when carboniferous iron is cooled it expands in the act of solidifying. By suddenly quenching iron, a solid layer or crust is produced outside the molten metal. When, therefore, the inside layer commences to solidify, it expands as it solidifies, and thus, as it is encompassed with the solid crust, enormous pressure is exerted. When quite cold the iron was dissolved away by means of acids, and there were left behind minute crystals of diamond. Moissan melted the iron in a carbon crucible with a current of 1,000 amps. at 60 volts, a temperature of between 3,000° and 4,000° C. thus being obtained. Crookes, in 1897, confirmed Moissan's work, and again in 1905 Moissan published a further paper upon the subject. Shortly after Moissan published his work, in 1896, Professor Majorana, in Italy, also showed that pressure and high temperature were necessary. He heated a piece of charcoal between two carbon electrodes, and then, while incandescent, drove it with great force into a hole in a steel block. In 1905, Sir Andrew Noble exploded cordite in closed steel cylinders, a temperature of 5,100° was obtained, and a pressure of 50 tons per square inch. Sir William Crookes examined some of the carbon deposited, and found it to contain minute diamonds. "Although electricity has been successful in unravelling nature's secret of manufacturing the diamond, it is not probable that diamonds will ever be manufactured. We have no conception of the enormous forces exerted by nature in the earth's interior, where masses of molten metal and rocks are cooled slowly. And this is really the point, we cannot conduct our experiments upon a sufficiently large scale, and cool with sufficient slowness, to ever expect to obtain large crystals of diamonds."

Iron and Steel.

Electric Smelting of Iron Ore.—When reporting, in our October issue last year, on Dr. J. W. Richards' American Electrochemical Society paper, entitled "Discussions of the Experiments at Sault Ste. Marie on the Electric Reduction of Iron Ores," we promised to give a somewhat more complete review of the paper when it would be available in print. It has now appeared in the twelfth volume of the *Transactions of the American Electrochemical Society*. The paper first gives tables of the analysis of the ores, reducing agents and fluxes employed and of the slags and pig irons produced and then sums up briefly results of the furnace runs. Material and heat balance sheets are given of several of the runs and the general conclusions of this analysis, which supplement our notes in Vol. V, p. 446, are summed up as follows:

Too much carbon was used in every case, not allowing a good utilization of the heat of oxidation of carbon in the furnace. A smaller proportion of carbon, more perfectly consumed to CO₂, would generate more heat, and thus help the furnace along. In the runs given, the electric current furnished about two-thirds of the energy required for all purposes, the carbon, one-third. Gas analyses, temperature of gases and calorimetric determinations of the heat in liquid pig iron and slag should be made in all cases, since important data depend on them. The consumption of fixed carbon was 240 to 380 pounds per 1,000 of pig iron—24 to 38 per cent of the weight of pig iron. With a larger production of CO₂, even lower than 24 per cent should be possible, for in this case

only one-fifth of the carbon burned to CO_2 . The conditions for economical reduction and large output are:

(a) A high column of charge, to allow of reduction by CO gas.

(b) Uniform size of charge, and not too fine, so that the gases may evenly, slowly and uniformly permeate and reduce the charge.

(c) To be content with white pig iron. If high-silicon, gray iron is desired, add ferro-silicon made in another furnace to the melted metal. If sulphur is high, add carbosulfurum waste or a silicon-calcium ferro-alloy. These will make the iron gray and remove sulphur without requiring the whole charge to be very intensely heated to the high temperature otherwise required. This division of labor, employing a small furnace at a very high temperature to make ferro-silicon, and running the large reduction furnace at a moderate temperature to make pig iron, seems to be a desirable economic combination.

Cutting Steel Structures with the Oxy-Acetylene Burner.—We have repeatedly referred in our columns to the method of cutting steel plates or structures with the aid of an oxy-acetylene burner which is essentially like an ordinary oxy-acetylene burner for welding purposes, but has an additional oxygen supply pipe; the principle is to first heat the steel to a very high temperature with the oxy-acetylene flame and then, by directing a stream of pure oxygen on the very hot plate to start autogenous burning. This method is stated to be extremely easy and the cut produced is said to be as sharp as made with a saw. The method is in commercial use in Europe for cutting steel plates, etc. An interesting application of the method is recorded to *Acetylen für Wissenschaft und Industrie*, Jan. 15. A transatlantic steamer had run in night time against an iron bridge which crosses the channel between the Bassin d'Enre and the Bassin Bellot in France. The bridge, which had a length of 50 meters, a breadth of 7 meters and a weight of 250 tons, was thereby entirely deformed and distorted so that no ships could pass the channel. Since several steamers wanted to leave the next day, it was soon found that it would be necessary to take the bridge down. This was tried with sawing, but it was found that this would take at least a week. Then the oxy-acetylene method was applied and the job was completely finished within scarcely 20 hours.

Lead.

Electrolytic Treatment of Galena.—In the November issue of the *School of Mines Quarterly*, E. F. Kern and H. S. Auerbach describe experiments made on the treatment of galena by means of a molten salt electrolysis for the cathodic reduction of galena. (The subject is of considerable interest in connection with the processes of Ashcroft, Betts and Townsend, described and discussed in our issue of May, 1906.) Fused alkali chlorides or fused calcium chloride served as electrolyte for the cathodic reduction of galena. The former have the advantage over calcium chloride in that the voltage of decomposition is much less. An e.m.f. of about 5 volts is required for the decomposition of the alkali chlorides and sulphides, whereas about 2 volts is required for calcium chloride and sulphide. Fused calcium chloride has an advantage over fused alkali chlorides for the cathodic reduction of galena, in that it is less readily volatilized, and is also a more fluid bath. At temperatures above $1,300^\circ \text{C}$. the fused alkali and calcium chlorides rapidly attack sand and clay crucibles, forming a hard, glassy slag. Below $1,000^\circ \text{C}$. the crucibles are scarcely affected other than becoming impregnated with the fused salts.

With a fused electrolyte of cryolite and fluorspar a higher current efficiency was found, which is accounted for by the fact that aluminium does not readily alloy with lead, for which reason it floats on the lead and is in more intimate contact with the galena than is the case with sodium or calcium, both

of which readily alloy with lead. A great disadvantage of the use of fluoride electrolytes is that the bath becomes quite viscous with use, which is due no doubt to the solubility of lead sulphide in the molten mass. The chlorides have quite an advantage over the fluorides in that when the bath becomes contaminated with foreign matter, such as SiO_2 , CaO , FeO , etc., the chloride salts may be dissolved by water, recrystallized, and are ready to be reused.

At the beginning of the operation of electrolysis for the cathodic reduction of galena, when chloride electrolytes are used, considerable chlorine is given off, the calcium or sodium which is at the same time freed reduces the galena forming metallic lead and calcium or sodium sulphides. After a certain amount of calcium sulphide or sodium sulphide has formed, the decomposition of the chloride ceases, because the e.m.f. of decomposition for sulphides is less than it is for chlorides. The sulphur, which is liberated at the anode, distils and may be collected in its elemental form, or allowed to oxidize and escape as SO_2 fumes. The highest current efficiencies, when chloride electrolytes were used for the cathodic reduction of galena, were obtained when the temperature of the electrolyte was highest. The high temperature is necessary to bring about reaction between the galena and the alloy of lead with either sodium or calcium.

When natural galena ore was treated, the current efficiency was very low. This is due to the galena being a poorer electrical conductor than the artificially prepared lead sulphide, and also to the temperature of the electrolyte not exceeding 923°C . However, when the mass was remelted under a covering of fused salts, and held at a temperature of about $1,200^\circ \text{C}$., the calcium which had alloyed with the fused lead cathode was liberated and reduced the galena which was floated on the lead.

No lead is lost by volatilization during cathodic reduction of galena, in a fused electrolyte, as the reduced lead is covered with a bath of fused salts, which is below the boiling point of the metal. Fused electrolytes, containing lead salts, even though having lower freezing points, are not suitable for the cathodic reduction of galena, because as lead stands lower in the e.m.f. series than the alkalis, and alkaline earths, it would be the first constituent to decompose, thus robbing the electrolyte of the constituent which lowered its freezing point.

In the course of the investigation a series of freezing points of salts and salt mixtures were determined, which should be quite valuable. They are herewith reproduced.

Summary of Freezing Points of Salts.

$\text{NaCl} = 792^\circ \text{C}$.	$\text{NaF} = 965^\circ \text{C}$.
$\text{CaCl}_2 = 772^\circ \text{C}$.	$\text{PbF}_2 = 552^\circ \text{C}$.
$\text{KCl} = 766^\circ \text{C}$.	$\text{KF} = 262^\circ \text{C}$.
$\text{PbCl}_2 = 494^\circ \text{C}$.	$\text{PbS} = 1025^\circ \text{C}$.
$\text{MgCl}_2 = 158^\circ \text{C}$.	Galena = $950^\circ - 1010^\circ \text{C}$.
Fluorspar (CaF_2) infusible at 1200°C .	
Cryolite ($\text{AlF}_3 \cdot 3\text{NaF}$) $935^\circ - 990^\circ \text{C}$.	

Mixtures:

10 NaCl	+ 1 KCl	$= 787^\circ \text{C}$.
5 NaCl	+ 1 KCl	$= 750^\circ \text{C}$.
2 NaCl	+ 1 KCl	$= 686^\circ \text{C}$.
10 NaCl	+ 1 CaCl_2	$= 790^\circ \text{C}$.
5 NaCl	+ 1 CaCl_2	$= 722^\circ \text{C}$.
2 NaCl	+ 1 CaCl_2	$= 720^\circ \text{C}$.
10 NaCl	+ 1 PbCl_2	$= 770^\circ \text{C}$.
5 NaCl	+ 1 PbCl_2	$= 761^\circ \text{C}$.
2 NaCl	+ 1 PbCl_2	$= 723^\circ \text{C}$.
10 KCl	+ 1 PbCl_2	$= 764^\circ \text{C}$.
5 KCl	+ 1 PbCl_2	$= 714^\circ \text{C}$.
2 KCl	+ 1 PbCl_2	$= 633^\circ \text{C}$.

10	CaCl_2	+ 1	PbCl_2	= 764° C.
5	CaCl_2	+ 1	PbCl_2	= 740° C.
2	CaCl_2	+ 1	PbCl_2	= 710° C.
10	Cryolite	+ 1	NaCl	= 955° C.
5	"	+ 1	NaCl	= 905° C.
2	"	+ 1	NaCl	= 862° C.
10	"	+ 1	KCl	= 940° C.
5	"	+ 1	KCl	= 909° C.
2	"	+ 1	KCl	= 900° C.
10	"	+ 1	NaF	= 950° C.
5	"	+ 1	NaF	= 910° C.
2	"	+ 1	NaF	= 877° C.
10	"	+ 1	KF	= 955° C.
5	"	+ 1	KF	= 920° C.
2	"	+ 1	KF	= 903° C.
10	"	+ 1	CaF_2	= 960° C.
5	"	+ 1	CaF_2	= 895° C.
2	"	+ 1	CaF_2	= 910° C.

RECENT METALLURGICAL PATENTS.

Iron and Steel.

Alloying Steel with Titanium.—If titanium is to be used as a seasoner or purifier for steel, a great difficulty is found in thoroughly and uniformly alloying the steel with the titanium on account of the high melting point and the low specific gravity of titanium. The titanium has a tendency to rise and float upon the surface of the molten bath; this produces a cooling effect and prevents the desired incorporation of the titanium into the steel, besides oxidizing the titanium in contact with the atmosphere. Mr. A. J. Rossi, who has already done so much to introduce titanium into steel practice, overcomes this difficulty in a recent patent (877,518, Jan. 28, 1908, assigned to Titanium Alloy Mfg. Co.) by covering the steel bath containing the titanium with a slag or "blanket," which prevents loss of heat by radiation and is impervious to those elements of the atmosphere which it is desired to separate from the bath. For such a slag or blanket, common slag run from ordinary blast furnaces in the usual production of the lower grades of pig iron may be used. A suitable composition is 40 per cent silica, 15 per cent alumina, 35 lime and 10 magnesia. The slag may also advantageously contain some titanium oxide, for instance 25 per cent silica, 25 titanic acid, 25 lime, 15 alumina and 10 magnesia. If the operation is carried out in the crucible the slag already formed and solid may be charged in along with the metal to be treated or it may be introduced after fusion of the latter and along with the ferro-titanium. If the operation is carried out in the ladle it is preferable to first introduce the ferro-titanium at the bottom of the metal and then pour the molten metal to be treated and finally add the slag blanket by pouring it in molten state over it.

Zinc.

Treatment of Complex Sulphide Ores.—A cyclic process for the treatment of complex zinc ores like the Broken Hill deposits is the object of a patent of Guy de Becchi (880,775, March 3). The ore is first ground to an impalpable powder and is then heated to ebullition with an acid solution of ferric sulphate (the free acid being only necessary for the subsequent regeneration of the ferric solution). The zinc is thereby dissolved as zinc sulphate, while the sulphur remains with the insoluble residue containing all the lead compounds and gangue matter. The reaction is indicated by the equation $\text{ZnS} + \text{Fe}_2(\text{SO}_4)_3 = \text{ZnSO}_4 + 2\text{FeSO}_4 + \text{S}$. The insoluble residue is dried and heated in a closed vessel so as to recover the sulphur

by distillation, after which the remainder of the residue is treated for the extraction of the lead in the usual way. The filtrate or solution which contains the soluble zinc sulphate quite free from lead and the iron chiefly as ferrous sulphate is now treated so as to oxidize the latter to ferric sulphate. For this purpose nitrate acid may be used, the nitrous fumes evolved being transformed into nitric acid by any wellknown means. The solution now contains only the ferric sulphate together with the zinc sulphate formed during the leaching, and by suitably cooling only the zinc is separated out as zinc sulphate crystals, while the ferric sulphate remains in the mother liquor. The zinc sulphate crystals are dried and calcined in a muffle furnace, the acid fumes evolved being passed into the ferric sulphate solution from which the zinc sulphate crystals have separated out or are absorbed by water so as to condense the fumes to sulphuric acid. The ferric sulphate solution may then be used again to leach a fresh quantity of ground ore. The zinc oxide obtained from the calcining of zinc sulphate is nearly pure.

The process is cyclic in theory but in practice nitrate of soda in small quantities must be used to make good the mechanical losses in regenerating the ferric sulphate solution. If copper, silver and gold are present, they remain with the lead residue and are recovered by the lead smelting. When the ore contains iron and manganese they are dissolved as sulphates by the ferric sulphate. Under such circumstances the amount of iron continually increases in the solution. It then becomes necessary to purify the solution by precipitating the iron as ferric hydrate or insoluble basic sulphate, by means of zinc oxide obtained from a previous operation. When the ore contains manganese the latter goes as sulphate into solution until the solution is saturated with it; after that all the manganese sulphate formed remains with the lead residue. It is claimed that the process gives a clean separation, yielding a pure zinc oxide free from lead.

Gold and Silver.

Pressure Filter.—D. J. Kelly, of Salt Lake City, patents a method of loosening caked solid material from the sides of

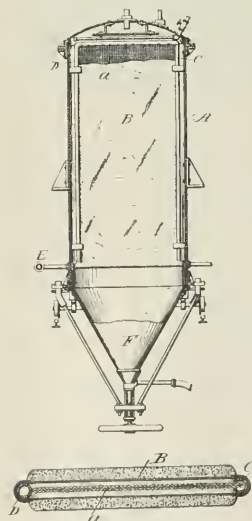


FIG. 1.—PRESSURE FILTER.

porous pressure filters (880,742, March 3, assigned to Kelly Filter Press Co.). The upper illustration of Fig. 1 shows a pressure filter tank and the pressure filter diaphragm separated therefrom, while the lower diagram is a cross-section of the filter diaphragm. A is the pressure tank and B the pressure filter in it being of canvas or other fabric and forming a tight bag-like enclosure, upon the outer surface of whose porous sides the solid material is collected in cake form. Within this hollow filter is a foraminous plate *a*, and along the sides of this plate within the bag are the pipes *c* and *d*. One of these, *c*, is slotted longitudinally to receive the separated liquid and carry it off, while the other *d* is a steam pipe leading from a main *e*. The material to be filtered is delivered into the tank under pressure and the pressure forces the liquid constituents through the pores of the canvas to

the inside of the bag, whence it is delivered by pipe C. The solid constituents of the solution being too coarse to pass through the pores of the canvas, form a cake on the outside. When this cake builds up to the desired thickness the supply of solution is cut off and the excess liquid, having been drained from the pressure tank and the bottom F of the same removed, steam is admitted through the pipe D. This steam forms a thin moist film on the surface of the cake and the latter sticks off and the cake is discharged by gravity in compact form through the open bottom. The inventor claims that steam is preferable to either water or compressed air, since by the use of the latter two the cake is disintegrated.

Thermit Welding in American Practice.

While the eminent position of Germany as a manufacturer of chemical products is chiefly due to the wonderful and enormous growth of its industries in the field of organic chemistry, it has also been the starting point of some exceedingly clever and highly successful developments in industrial inorganic chemistry. In this respect the two owners of the largest plant for inorganic chemistry in Germany, the chemical and tin smelting works of Th. Goldschmidt, of Essen-Ruhr, Dr. Karl Goldschmidt and Dr. Hans Goldschmidt, have been the leaders along two different and commercially very important lines—the detinning of tin scrap and the aluminothermic method.

Both of these industrial developments are now of international importance. Since it has been the privilege of this

ful whether such alloys could commercially compete with aluminium. While it is quite possible that the name "aluminothermics" may be changed some day, it is certain that for the present, and for some time to come, thermit will remain in composition what it has been in the past, a mixture of powdered aluminium and iron oxide.

The reaction between aluminium and iron oxide yields alumina and iron with such a surplus of heat that the iron is

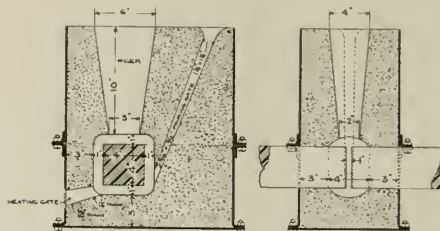


FIG. 2.—VERTICAL CROSS-SECTIONS THROUGH MOLD.

obtained in a greatly superheated fluid condition. Prof. Ostwald has once expressed this fact in the clever remark, that in thermit we have a blast furnace in the vest pocket. It is clear that the possibility of getting any amount of highly overheated liquid steel within a fraction of a second wherever it is wanted, naturally opened a wide field of commercial applications, and American iron and steel men and manufacturers in general were quite quick to make use of these possibilities. This is indicated by the rapid growth of the Goldschmidt Thermit Company—the owner of the American patents—since its formation in 1904. The new Jersey City works of the company are shown in Fig. 1.

Among the modifications of the process which have been introduced into practice during the past year are two of special



FIG. 1.—JERSEY CITY WORKS OF GOLDSCHMIDT THERMIT CO.

journal to publish in the past a number of authoritative articles on aluminothermics and kindred subjects from the pen of the inventor, Dr. Hans Goldschmidt, it will be of interest to review here briefly the attainments of aluminothermics in American practice. For it is an interesting fact that through the co-operation of American engineers and users of thermit, the procedure of welding with thermit in commercial practice has undergone some very striking modifications.

The principle has remained, of course, unchanged. The very high affinity of aluminium for oxygen, as indicated by the heat of combination, was a direct suggestion of making use of this heat, after the production of aluminium at a low cost had become possible by electrochemical means. It is just as natural that attempts are now being made to try and find a substitute for aluminium in form of some other element which also has a very high oxidation heat.

Dr. Hans Goldschmidt's recent work in this direction was reviewed on page 79 of our February issue. It appears, silicon alone (as substituted for aluminium) will not do, nor will calcium alone do, but a calcium-silicon alloy or a calcium-aluminium alloy can be successfully used for certain purposes. However, with the present price of metallic calcium, it seems doubt-



FIG. 3.—MOLD BOX AND CRUCIBLE IN POSITION.

importance. One is the preheating of the sections to be welded, the other is the use of yellow wax as a matrix or pattern for the mold.

Preheating by means of a gasoline torch the sections to be welded afterwards by the thermit reaction, is of great importance in view of the necessity of producing an absolutely homogeneous, uniform weld. Without preheating, the cold sections will conduct some of the heat rapidly away, when the superheated fluid thermit steel comes in contact with them. The portions of the casting, near the welding line, will become more or less plastic and there will a gradual, but rapid temperature drop within them. Then, on account of the non-uniformity existing there, mechanical stresses will be set up

when the metal contracts on cooling, so that there is a liability of formation of blowholes near the weld. If the sections to be welded are properly preheated, this danger is very largely reduced, and, as a matter of fact, the method of preheating, since its introduction into practice, has proven very successful.

The method of preheating, used in practice, will best be described in connection with the use of yellow wax for the pat-

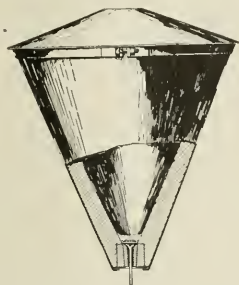


FIG. 4.—CRUCIBLE WITH PLUGGING MATERIAL.

tern of the mold. In any case of a thermit repair, the fracture is first opened up by drilling a series of holes along the line of the break, or the metal is cut away, so as to get an open space for the free flow of the thermit steel between the parts to be welded together. Then follows the making of the mold.

The principle guiding the construction of the mold will be best understood from Fig. 2, showing two vertical cross-sections through the mold. The right-hand diagram shows the two ends of a broken axle to be welded together; it shows the space which is left open between the ends and the space for the reinforcing collar around them. The method of pouring the thermit steel is best seen from the left-hand diagram, but it should be understood that at the moment of pouring the ther-

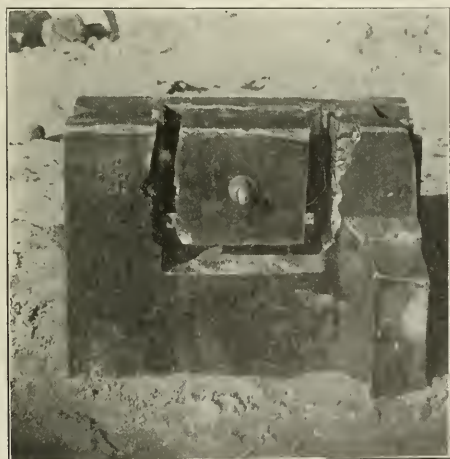


FIG. 5.—STEEL HAMMER BEFORE WELDING, AFTER CUTTING OUT THE SECTIONS TO BE REPAIRED.

mit steel, the hole in the bottom, marked "heating gate," is closed; the liquid superheated thermit steel is run through the "pouring gate" to the lowest point of the mold and rises through and around the parts to be welded and into the large "riser."

The mold was formerly made in two pieces, which were formed over a wooden pattern. They were then taken apart, the pattern withdrawn, and the pieces put together again, which was followed by the welding operation proper. It was then very difficult to preserve the alignment of the broken sections during welding. With the new method of using yellow wax for the pattern the construction of the mold is as follows:

After the sections to be welded have been put in proper position, the open space between the two sections and the space intended for the collar around the weld is filled with yellow wax. That is, the wax takes exactly the shape which the thermit weld is to take afterwards. Then the molding sand, which consists of fire clay and sand, is tamped around the matrix in the usual manner, but a small hole is left at the very lowest part of the mold (indicated in Fig. 2 as "heating gate"). The patterns for the "running gate" and the "riser" are made of wood.

When the mold box is in position and completely filled, the wooden runner and riser are withdrawn and a gasoline torch

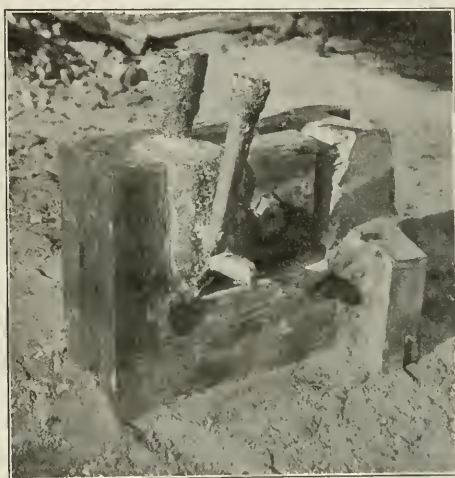


FIG. 6.—AFTER COMPLETION OF ONE WELD, THE RISERS NOT HAVING BEEN REMOVED.

is directed into the heating gate, directly onto the green sand. This serves three purposes. First, the yellow wax is melted and runs out of the "heating gate," which is then closed with a sand core. Second, the mold is thoroughly dried. Third, the two sections to be joined are brought to a bright red heat.

Now, when they are thoroughly preheated, the thermit reaction is started and the fluid steel is poured into the "running gate." Fig. 3 shows the mold box and crucible in position, and the sections being heated by the gasoline torch.

More thermit steel must be poured than is necessary to fill the space taken up by the weld proper. The reason is that the first thermit steel which runs out of the crucible into the mold is chilled when coming in contact with the casting, since the latter, though preheated, has a considerably lower temperature than the thermit steel. This chilling effect is overcome by using a sufficient quantity of thermit steel so that the chilled portion is driven up into the riser, and its place is taken by fresh thermit steel which has practically the full temperature produced in the aluminothermic reaction.

When larger quantities of thermit are used, it is necessary to mix steel punchings or particles of steel, free from grease into the thermit powder. The intensity of the heat of the reaction is thereby moderated without interfering with the effi-

ciency of the weld. An addition of 2 per cent of pure manganese is also recommended; and, in fact, it is quite possible and often advisable to introduce small quantities of manganese, nickel, chromium, vanadium or other metals into the thermit steel for certain classes of repair.

The thermit reaction itself takes place in a cone-shaped magnesite-lined crucible, as shown in Fig. 4.

First, a scarfed pin is suspended in the opening, so that its lower end projects about 2 in. below the crucible. Over this are placed some asbestos washers, then a round metal disk. These are rammed firmly into place, after which a layer of refractory sand is placed on top.

The thermit powder is next poured into the crucible and in the middle is placed a pinch of ignition powder. This may be ignited by applying a storm match, or a small bundle of parlor matches immediately after they have been struck. By this the chemical reaction is started and continues throughout the rest of the mass. The resulting superheated liquid steel sinks to the bottom of the crucible, from whence it is tapped into the

for repairing especially broken locomotive frames and spokes of drivers, in the latter for repairing motor cases and truck sides.

Another field in which the thermit process is steadily increasing in importance is the welding of pipes. This is of very great importance for compressed-air and ammonia installations, cold-storage plants, etc., since by welding the pipes with thermit an absolutely continuous pipe is produced without any possibility of leakage. The cost of producing a continuous pipe by welding with thermit is a very small item compared with the continuous cost of leakage in plants of the types mentioned.

The old application of the thermit process to marine repairs is also steadily gaining in favor, since the advantages of a quick repair without necessity of putting the ship into a dry dock are self-evident.

In general, it may be said that the thermit process may be applied to all kinds of repairs of steel castings and wrought-iron castings. Repairs of gray-iron castings, on the other hand, are a risky undertaking with the process, since the heat of the reaction creates strains in the castings at points away from the weld.

Figs. 5, 6, and 7 illustrate the repair of a large steel hammer recently carried out with thermit at the Jersey City works of the Goldschmidt Thermit Company. This steel hammer was 24" high, 10½" wide, and weighed 800 pounds. A large piece of metal was broken out, as shown in the illustrations, and in order to put it back into place, it was necessary to make two thermit welds, one on each side. The method followed in doing this work was the same as described above. Each weld required 50 pounds of thermit, one pound of metallic manganese free from carbon, and 7½ pounds of mild steel punchings.

Fig. 5 shows the steel hammer ready for repair after cutting out the spaces where the welding is to be done.

Fig. 6 shows one weld completed, the risers not having yet been removed, so that this figure is a good illustration of the method shown diagrammatically in Fig. 2.

Fig. 7 shows the two welds completed and the risers removed.

A New Analytical Balance.

William Ainsworth & Sons, the well known manufacturers of balances and engineering instruments, of Denver, Colorado, have just placed upon the market a new analytical balance of 200 grams (8 ounces) capacity and one-twentieth milligram sensibility, having several improvements.

The case is of French polished mahogany with counterpoised sliding door in front and sliding door in rear that can be removed to admit of the weighing of long tubes and apparatus that would not go inside the case. A glass sub-base covers the entire top of the base, which is provided with four leveling screws, instead of three as usually furnished.

All the metal work is gold-plated excepting the center bearing and yoke, which being finished black make a pleasing contrast.

The beam, Fig. 2, is made of hard-rolled nickel-aluminum 6 inches long, and divided into 100 parts, either side of the center to use a 10 milligram rider. The edges are of solid agate set rigidly in the beam, and when once adjusted will remain in position indefinitely.

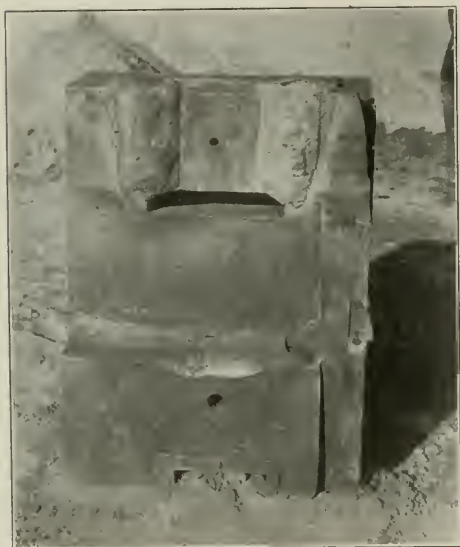


FIG. 7.—WELD COMPLETED.

mold by giving the tapping pin a sharp knock upwards and the liquid thermit steel runs directly into the gate of the mold.

While we have given here only a general description of the procedure, the Goldschmidt Thermit Company have worked out very exact and simple rules as to the accurate quantities of thermit to be used in any given case, the amount of steel punchings to be added, etc. These rules may be found, for instance, in the first issue of "Reactions," the new and very interesting quarterly publication issued by the Goldschmidt Thermit Company. A note concerning this new trade publication appears elsewhere in this issue.

The chief application of the thermit process is still for rail welding on electric street railway roads where the rail is used for the return circuit. A continuous rail is thereby produced. This method is used now by some 75 American street railway companies. If the new single-phase system should find larger application on main roads, there will certainly be good prospects for the process also in this field.

Large quantities of thermit are also being used in railway repair shops and in street-railway repair shops; in the former

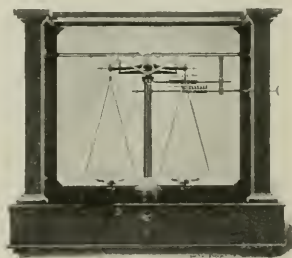


FIG. 1.—BALANCE.

The Ainsworth improved multiple rider carrier, Fig. 3, is used for handling all weights below one gram.

It is simple in operation and to transfer any weight to the stirrup it is only necessary to move the lower rod longitudinally by means of the thumb-piece extending outside the case, until the number corresponding to the weight to be shifted stands



FIG. 2.—BEAM OF BALANCER.

opposite the index, when a slight revolving motion transfers the weight; the numbers on the arms that are down indicating the value of the weights on the hanger.

When through weighing, a slight revolving motion of the rod replaces all weights simultaneously. Each weight or rider has its own individual arm and cannot become displaced in ordinary working.

The improved rider apparatus, Fig. 4, is similar to that used on their assay balances, and is so constructed that the carrier



FIG. 3.—MULTIPLE RIDER CARRIER.

arm can never touch the beam nor can the rider be thrown off the beam, excepting through gross carelessness.

This illustration also shows the swinging yokes which are pivoted at a point coinciding with the contact point of the center edge, so that the yokes at the end may pick up the stirrups at any point of the arc through which they swing without sliding the end bearings on the edges.

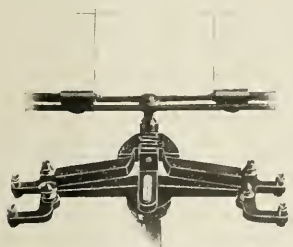


FIG. 4.—RIDER APPARATUS.

Fig. 5 shows one of the skeleton hangers used on this balance, which, owing to its construction, does not catch dirt, thus throwing the balance out of adjustment.

This construction admits of the use of a pair of metal plates or a pair of glass pans, or one plate and one pan, in either

hanger, they being adjusted so that either will balance the other. This balance, together with the complete line of instru-



FIG. 5.—SKELETON HANGER.

ments made by William Ainsworth & Sons is illustrated and described in Catalog A-4, which will be sent on request.

Electric Distilling Apparatus.

The latest of all commercial applications of the electric current has been electric heating. In spite of the comparatively high price of electric energy for heat, this application makes steady progress on account of the great cleanliness, convenience and ease of the operation. Street-railway cars and yachts are now not only operated and lighted, but also heated by electricity. Soldering and laundry irons are now heated electrically and many culinary devices are operated by the same method of electric heating.

Probably the latest application in this field is the use of



ELECTRIC WATER STILL.

electric heat for the continuous distillation of water for laboratory and other purposes. Messrs. E. H. Sargent & Co., of Chicago, have perfected such an appliance, which is simple, easily cleaned, durable, and has a capacity of one gallon per hour of pure distilled water, and the cost of the apparatus is stated to be not higher than that of other systems of operation, while the cost of installation is much less than when steam or gas has to be piped in.

The apparatus consists of a shallow retort presenting a large surface for evaporation and a very thin film of water to the action of the heat-producing unit. The condenser is a circular trough in form, in which the condensing coil is laid with sufficient fall to discharge the distilled water promptly. The cooling water is allowed to flow continuously into the trough, from which it is conveyed into the retort for evaporation, any surplus being carried off by an overflow system.

For cleaning purposes, the entire top of the retort is easily removed, providing access to the solid residue through an opening 10 inches wide, into a pan only 2 inches deep, similar in

form to a frying pan. The entire still is block-tin lined. The apparatus stands on three legs, and may be placed on a table or on a shelf against the wall. It is especially designed for use by institutions manufacturing their own light and power, or where steam or gas are not desirable or cannot be obtained. It is attached indiscriminately to a direct or alternating current of 110 volts, but may be obtained for 220 volt current, if so desired.

Notes.

American Electrochemical Society.—At the meeting of the board of directors, held on Feb. 29, the following gentlemen were elected members: Herbert C. Jannison, Coe Brass Manufacturing Company, Ansonia, Conn.; Percy A. Boeck, Norton Emery Company, Worcester, Mass., and William C. Marti, University of Illinois, Urbana, Ill. At the board meeting to be held in Philadelphia, on March 25, the names of the following gentlemen will come up for election to membership: Louis E. Ward, Dow Chemical Company, Midland, Mich.; Dr. Y. Bavorovsky, University of Prague, Prague, Bohemia; S. T. Hansen, Jr., Missouri River Power Company, Helena, Mont. Membership certificates have now been engraved and may be had from the secretary at the price of \$1. The preliminary program of the meeting of the society, to be held in Albany, Schenectady and Troy on April 30 and May 1 and 2, will be found on page 138 of the present issue.

Oil Firing.—A recent pamphlet of the Schutte & Koerting Company, of Philadelphia, gives an illustrated description of two methods of oil firing. The first is the Koerting oil-firing system with centrifugal spray nozzles for marine or stationary boilers and locomotives, providing for strict economy and reliable service. The second method is a system for steam-jet oil burners, providing a low cost of installation in small plants where the fuel is of a thick nature (tar, etc.) and giving reliable service.

Synthetic Perfumes.—The second number of the *Synflour Herald* was issued some time ago, and is an excellent example of a useful trade publication. It is "published periodically, as we find time" by Mr. Alois von Isakovics, proprietor of the Synflour Scientific Laboratories, Monticello, N. Y. This issue contains a vast amount of exact and useful information on the synthetic preparation of perfumes, hair tonics, face powders, tooth powders, fruit flavors, fruit oils, etc., from the essences made by the publisher.

Galvanizing Barrel.—The United States Electro-Galvanizing Company, of Brooklyn, N. Y., have recently issued an illustrated pamphlet on their automatic galvanizing barrel. This device is quite interesting, since, by its employment, it is claimed that small material can be galvanized satisfactorily at an average cost as low as 30 cents per 100 lb.

The Traylor Engineering Company of New York City, issue each month a little calendar on cardboard and make excellent use of the back, by printing thereon useful and reliable information for mining and metallurgical engineers. Thus the February calendar contains data sheet No. 14, on the determination of a concentrating ore, while data sheet No. 15 contains "a treatise on rope and common knots."

Grinding and Separation.—We have received from the Raymond Brothers Impact Pulverizer Company, of Chicago, an illustrated pamphlet on the Raymond system of grinding and separating. The apparatus is a combination of a roller mill with an air-separation system. The chief feature is the principle of "air separation," which is based on the observation made in every-day life that a current of air passing over fine particles of dust, etc., will carry these particles with it and that in proportion as the speed of the current is increased it will pick up heavier particles. By regulation of the air current in the Raymond separator, powder of any degree of fineness

can be separated and carried to the point of storage, while perfect uniformity of fineness is assured. The system is quite interesting, and we hope to describe it more in detail in a future issue.

Tanks and Tank Towers.—We have received the new 1908 catalog of the W. E. Caldwell Company, of Louisville, Ky. As is well known, this company has made for the past 30 years a specialty of the designing and building of tank towers, and of foundations on buildings for tanks. Their tank towers are of two general designs: one a sectional tower coupled with heavy sockets, and the other a latticed column tower with the sections riveted together. The former design is furnished with either tubular columns or angle columns. The company also makes an all-wood tower and a combination structure with wooden columns and struts and steel brace rods. The business of the company extends into every part of this country, as well as to Canada, Cuba, Mexico, Central and South America. The pamphlet is illustrated and contains price lists.

Primary Battery.—In our Analysis of Current Electrochemical Patents we have repeatedly mentioned patents granted to Mr. C. E. Hite for a new primary battery. This has now been placed on the market by the Hite Electric Company, of Philadelphia. It is made in six different sizes; in two of them, three external circuit connections are available, so as to give three different voltages. It is intended to be used for all purposes for which sal-ammoniac cells are now being used, and is claimed to be easier, cleaner and more convenient to handle.

Mr. William M. Davis is now established independently at 93 Broad Street, Boston, as a lubrication engineer and specialist in all that pertains to practical and scientific management of lubrication costs in manufacturing and other establishments in which lubricants are a factor of the operating expense. Mr. Davis will especially make tests and analyses of lubricating oils, inspect and report on lubricating conditions and requirements with a view to reducing costs, and prepare specifications for lubricating oils.

Dr. Gustave M. Westmann died in New York City on March 6. A Swede by birth, he was, in his younger years, instrumental in introducing the open-hearth process in Russia and was also interested in the lumber business in Finland. Later he came to this country. He invented many processes, especially relating to the iron and steel industry and to gas-power engineering. He was also the inventor of an electric arsenic furnace. During the last years he was very deeply interested in speculations on chemical thermodynamics.

Digest of U. S. Patents.

Compiled by *Byrnes, Townsend & Brickenstein*, Patent Lawyers, National Union Building, Washington, D. C.

CALCIUM CARBID (Continued).

656,590, Aug. 21, 1900, Reuben Doolittle, of Chicago, Ill.

Feeds a continuous stream or shower of a mixture of pulverized carbon with an oxide of calcium, strontium or barium downward through a vertical stack furnace. Lateral gas or oil burners enter the top of the stack, beneath which are superposed pairs of horizontal electrodes. An exhaust pump is connected to the lower end of the stack to create a draft. The several arcs, sprung between the superposed electrodes, increase in temperature downward. The ingredients of the charge initially react, taking nitrogen from the air supplied through the burners, with the production of cyanogen and acetylene. As the charge passes through the arcs, the calcium cyanide is decomposed at a temperature estimated at 1775° C., this decomposition being said to greatly increase the temperature. The produced carbid, falling to the lower end of the stack, may either be delivered into a truck, or cooled and granulated by a cooling jacket and blast. A grate is shown

at the lower end of the stack, in one modification, to retard the flow of the carbid during the first cooling and deliver it to the action of the blast, in small streams. The charge may consist of pulverized slack coal and limestone. The superheated gases exhausted from the lower end of the stack may be utilized.

657,736, Sept. 11, 1900, William Smith Horry, of Sault Ste. Marie, Mich.

The carbid furnace consists of a vertical cylindrical metal shell, in the upper part of which is a pair of depending electrodes. The furnace has a vertically-movable bottom, supported by a screw. Pointed screws pass laterally through the lower end of the furnace wall. An arc is sprung between the lower ends of the electrodes by placing fine coke on the bottom and raising it until the electrodes are short-circuited. A charge of charcoal and limestone, or of coke and lime, is fed into the open furnace-top, so as to bury the arc in three or four feet of material. When limestone is used, it is burned, in the upper part of the furnace, by the waste heat from the zone of reduction. As carbid forms, the attendant gradually lowers the furnace-bottom until finally it reaches its lowest position, the carbid protruding below the furnace. The pointed lateral screws are then turned inward, breaking off the projecting pig and supporting the furnace-contents. The bottom is then again raised, the screws retracted and the operation resumed. By burying the arc deeply in the charge, the escaping heat is utilized and the gases passing from the top of the furnace consists largely of carbon dioxide. Flames are not evolved and the materials are not blown out.

664,333 and 664,334, Dec. 18, 1900, John M. Morchead, of Chicago, Ill.

Employs two types of furnaces, one a stack, the other a wheel. The stack furnace has a closed upper end with a charge inlet and gas outlet. Beneath the furnace is a movable bottom. In use, an arc is sprung between the lower ends of depending electrodes, imbedded in the charge. As carbid is produced, the bottom is gradually lowered, allowing the pig of carbid to settle. A filling of unreduced charge is maintained between the pig and the furnace-walls, being supported at the lower open end of the furnace by hinged retainers bearing against the pig. This filling or packing excludes air. Beneath these retainers are lateral pointed screws to support the upper part of the pig and furnace contents when the projecting lower portion is broken off.

The other furnace is of the Horry wheel type. A hood, containing a pair of vertical electrodes, depends into the open receiving side of the wheel. The charge-mixture is delivered into the wheel around the hood, maintaining a seal around its lower end, thereby preventing ingress of air and directing gas into and confining it in the hood, from which it escapes through a pipe. Air being excluded from the zone of reduction in both furnaces, the carbon monoxid does not burn in the furnace or heat the electrodes or their holders.

NEW BOOKS.

THE METALLURGY OF IRON AND STEEL.—By Bradley Stoughton. 500 pages, illustrated. Bound in cloth. Price, \$3. New York: Hill Publishing Co.

MENSURATION FOR SHEET METAL WORKERS.—By W. Neubecker. Applied in working ordinary problems in shop practice. 51 pages, illustrated. Bound in cloth. Price, 50 cents. New York: David Williams Co.

PRINCIPLES AND PRACTICE OF ARTIFICIAL ICE MAKING AND REFRIGERATION.—By L. M. Schmidt. Comprising principles and general considerations; practice as shown by particular systems and apparatus; insulation of cold storage and ice houses, refrigerators, etc.; useful information and tables. Third edition, revised and enlarged. 460 pages, illustrated by 205 engravings.

Bound in cloth. Price, \$3. Philadelphia, Pa.: Philadelphia Book Co.

GAS POWER.—By F. E. Junge. A standard work on the generation, transmission and application of gas power. 640 pages, illustrated. Bound in cloth. Price, \$5. New York: Hill Publishing Co.

ELECTRICAL ENERGY: ITS GENERATION, TRANSMISSION AND UTILIZATION.—By E. Julius Berg. (Compiled from a series of lectures intended to bridge the theoretical instructions given in the ordinary university education and the practical problems confronted in commercial engineering. It is assumed that the student is in a general way familiar with the fundamental principles of electrical engineering and to some extent with the theories of the various phenomena and apparatus involved.) 195 pages, illustrated by diagrams. Bound in cloth. Price, \$2.50 net. New York: McGraw Publishing Co.

WHITTAKER'S ARITHMETIC OF ELECTRICAL ENGINEERING; for technical students and engineers; containing 72 worked examples and 300 exercises. 166 pages. Bound in cloth. Price, 50 cents. New York: Macmillan Company.

ESSENTIALS OF MODERN ELECTRO-THERAPEUTICS.—By F. Finch Strong. An elementary text-book on the scientific therapeutic use of electricity and radiant energy. 122 pages, illustrated. Bound in cloth. Price, \$1. New York: Rehnman Co.

THE THEORY OF OPTICAL INSTRUMENTS.—By Edmund T. Whittaker. 72 pages. Paper Cover. Price, 25 cents net. New York: G. P. Putnam's Sons.

BOOK REVIEWS.

EXERCISES IN ELEMENTARY QUANTITATIVE CHEMICAL ANALYSIS FOR STUDENTS OF AGRICULTURE. By A. T. Lincoln, Ph. D., Assistant Professor of Chemistry, University of Illinois, and J. H. Walton, Jr., Ph. D., Assistant Professor of Chemistry, University of Wisconsin. 8vo., 218 pages. Price, \$1.50 net. New York: The Macmillan Company.

This is a very carefully prepared work, intended as an elementary guide to beginners in chemistry who intend to specialize in agriculture. Our own opinion is that beginners ought not to specialize, but ought to learn chemistry at first just as chemistry; nevertheless, granting that such a limitation of the student's point of view is, *ab initio*, desirable, this work offers a very satisfactory outline of procedure.

The introduction gives the description of quantitative apparatus and their use, the balance, etc., in very lucid fashion. It is an admirable introduction for any beginner in chemistry. Part V gives in equally commendable fashion the principles of writing equations and making chemical calculations. This is also most excellently written, but why it should follow the main part of the book, instead of following the introduction, we cannot understand. Part II gives a very few gravimetric analyses, explained in minute detail, it is true, but surely not enough to acquaint the students with all the gravimetric procedure which they ought to learn. Incidentally we must dissent from the definition of a gravimetric method—as one in which the constituent is determined by transforming it into an insoluble compound. This is entirely too narrow; why not say, simply, that it is one in which the constituent is determined by ultimately weighing some material product whose weight bears a known relation to the weight of the constituent sought.

Part III, volumetric analysis, gives complete and very satisfactory directions for use of apparatus, making normal solutions, acidimetry, alkalimetry, oxidation, reduction and iodimetry. Part IV, the kernel of the book, gives the analysis of milk, butter, butter fat, cereals, feeding mixtures, fertilizers and soils.

Taken altogether, the book is very carefully written, and could hardly be improved on as an introduction to quantitative analysis for students specializing in agricultural chemistry.

TRANSACTIONS OF THE AMERICAN ELECTROCHEMICAL SOCIETY. Vol. XII. Twelfth general meeting, New York City, Oct. 17, 18, 19, 1907. 418 pages; many illustrations. Price, \$3. South Bethlehem, Pa.: American Electrochemical Society.

This is the largest volume so far published of the *Transactions* of the American Electrochemical Society. It contains the papers presented at the New York City meeting last autumn, a full report of which was given in our issue of last November.

Among the papers which were read by title at the meeting and which have now appeared for the first time in print are papers by J. W. Turrentine on electrolytic and chemical action of ammonium persulphate on metals, and by O. W. Brown and R. R. Sayers on the treatment of storage battery elements before putting them out of commission.

Without any reflection on the value of the balance of the papers contained in the volume, we may mention only three which are distinguished both by length and importance. These are L. H. Duschak and G. A. Hulet's paper on the silver coulometer (40 pages), H. E. Patten's paper on the electrolytic reduction of nitric acid (74 pages), and Henry Noel Potter's trilogy on silicon monoxide or monox (38 pages).

As an appendix is printed the part dealing with molybdenum of Mr. Gustave Gin's memoir on the methods of treatment of simple and complex ores of molybdenum, tungsten, uranium, vanadium (64 pages). It will be remembered that this memoir received the Frenzel prize. The translation has been made by J. W. Richards and W. L. Landis.

The frontispiece of the volume is a reproduction of a flash-light photograph taken at the banquet in Liederkrantz Hall. It is particularly interesting, as it is printed with Dr. Potter's "monox" ink.

* * * *

THE METALLURGY OF IRON AND STEEL. By Bradley Stoughton, Ph. B., B. S., Adjunct Professor, School of Mines, Columbia University; 8 vo., pages VIII + 510, 309 illustrations. Price, \$3. New York: Hill Publishing Company.

A very creditable presentation of the descriptive part of the metallurgy of iron and steel—blast furnace and puddling mills, crucible steel plants, bessemer converters, open-hearth furnaces, casting apparatus, hammers, rolls, wire-drawing plants, molding, cupolas, and electric furnaces. To give the beginner proper visual conceptions of these essential pieces of apparatus, probably no book in English is its superior; many of the illustrations are photographs, and the diagrams and drawings are very clear.

The explanations of the principles of the various processes are clear cut, concise and fairly accurate. They will give the student very definite ideas of what takes place in the operations, with some few erroneous notions here and there, which must be unlearned later by study of more authoritative works. The explanations given are, it may be inferred, not authoritative, but represent in most cases an opinion which at present is in process of revision, or has been already revised. It is just at this point that the student using the book will need the intelligent guidance of his professor, to set him exactly right in his conceptions of the rationale of the processes.

The statements of general ideas, elementary chemical principles, physical principles, mechanical principles, are usually clear and concise, but in many places not exact. Like those above referred to, their form is often open to objection, either through carelessness in the use of words or to a confusion of ideas. The statement, for instance, that "every gas expands $1/273$ of its volume for every degree Centigrade that its temperature is increased" is not true unless "its volume" as 0° C. is meant, and should be so stated. The author's illustration of this principle, immediately following, however, shows that he himself does not appreciate the law in its exact form. The illustration of Avogadro's law—the specific gravities of the

gases are proportional to their molecular weights—is equally unfortunate and erroneous. The author's explanation of the principles of electric induction, as illustrated in the Colby furnace, is inaccurate; but, as in similar instances cited, the description of the apparatus and the process itself is clear and good.

In handling the thermochemistry of the process, the author is again open to criticism. He starts out by saying that he will use gram-calories, but later on uses pound-calories, and also kilogram-calories, without any explanation, and, indeed, mixing the latter indiscriminately with gram-calories (as on p. 171, foot).

Throughout the work, many discoveries and explanations are credited to Prof. H. M. Howe, which the latter would be the first to disclaim. Prof. Howe may have revealed these to his assistant, Prof. Stoughton, but he certainly was not the first to publish them to the metallurgical world. Likewise, the explanation credited to Prof. C. F. Chandler, on p. 118, should have been submitted to him before being published.

Altogether, to be perfectly fair to the book and to give it its proper place in metallurgical literature, it is a remarkably good presentation, for the beginner, of the descriptive part of the metallurgy of iron and steel. As such, it ought to take a first place as a book of reference in our universities and technical schools. It is also full of useful facts and analyses concerning the processes involved, very carefully and assiduously collected. Its deficiencies are its weakness when discussing the chemical and physical principles involved, arising partly from carelessness and partly from insufficient information. These deficiencies limit its usefulness, and require that students using it should be carefully looked after on the side of theory by their preceptor, in order to avoid absorbing these mistakes.

The book is finely printed, remarkably cheap, and we wish it the large sale which it undoubtedly deserves.

* * * *

COAL-MINE ACCIDENTS: THEIR CAUSES AND PREVENTION. A preliminary statistical report. By Clarence Hall and Walter O. Snelling. With introduction by Joseph A. Holmes. 21 pages. Washington, D. C.: Department of the Interior, United States Geological Survey.

The number of men killed in the coal mines of the United States from 1890 to 1906 is 22,840. The number has increased from 701 in 1890 to 2,061 in 1906. Moreover the number of men killed per 1,000 men employed has increased from 2.67 in 1895 to 3.40 in 1906. On the other hand in European countries the same figure has decreased, due to mining legislation for the safeguarding and protection of the lives of the workmen. Thus in Belgium, 3.19 men for each 1,000 employed were killed in the period from 1831 to 1840 and 1.02 in the period from 1901 to 1906. Belgium maintains the most thoroughly equipped testing station in the world, and for a number of years has carried out extensive experiments to devise means to prevent accidents and to increase the safety of workers in the mines.

One-half of all the fatal coal-mine accidents in the United States in 1906 and 39 per cent of all the non-fatal accidents were the results of falls of roof and coal. It is pointed out that in European countries the use of excessive charges of explosives is prohibited by law, and definite limits are set as to the amount of any explosive that may be used. Although these regulations were framed with the object of preventing gas explosions, it is believed that they have been of marked effect in preventing accidents from falls of roof and coal, as the very great disturbing and jarring effect exerted by the discharge of large amounts of explosives in a mine is believed to be one of the most important causes of falls of roof.

The prevention of mine accidents is discussed under the following headings: Safety Lamps; Use of Explosives; Storage of Explosives; Shot Firers; Materials Used for Tamping; Watered Zones; Aid to the Injured; Enforcement of Regulations; and Study of Mining Conditions.

Electrochemical and Metallurgical Industry

VOL. VI.

NEW YORK, MAY, 1908.

No. 5.

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the

ELECTROCHEMICAL PUBLISHING COMPANY

239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH. D.....President
E. F. ROEBER, PH. D.....Editor and Secretary
C. E. WHITTLESEY.....Treasurer

Yearly subscription price for United States, Mexico and United States dependencies, \$2.00; for all other countries, \$2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, MAY, 1908.

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Albany Meeting of the American Electrochemical Society.

In our last issue we have already called attention to the exceedingly interesting program of the convention to be held from April 30 to May 2 in Albany, Schenectady and Troy. The meeting of the first day will be held in Albany, that of the second day in Schenectady, that of the third day in Troy. This kaleidoscopic change of scene, together with the various visits and excursions which have been arranged, should prove most attractive. The program of papers to be presented, as published on page 176 of this issue, is as full and diversified as ever and we note with pleasure that there are three lectures of great general interest on the program, the speakers being Dr. Bancroft, Professor Burgess and Dr. Steinmetz.

Plating Iron with Zinc

Iron and steel surfaces are coated with zinc, tin or paint principally for the purpose of providing protection against corrosion. The usual term "galvanized iron" for iron coated with zinc is unfortunate. There is no galvanic action *per se* in iron coated with zinc. Only if by chance or accident part of the iron surface is free from zinc and exposed to the atmosphere, then this part of iron, together with the surrounding zinc and the atmospheric moisture forms a short-circuited galvanic cell and there ensues an electric current from the zinc through the moisture into the iron. The zinc being the anode dissolves, while the iron as cathode is not attacked on account of the essentially reducing nature of every cathodic reaction. If there was any iron oxide present instead of metallic iron, it would be reduced to the metallic state by the current. This is the rationale of the protection of iron from rust by means of a zinc coating.

* * *

The interesting article in this number from the pen of Mr. Cowper-Coles, who is unquestionably one of the most competent men to discuss this subject, gives details of, and comparisons between, four different methods of coating iron with zinc. The first is the old and most generally employed method of dipping in molten zinc; while it may be in some respects less expensive than the other methods, as pointed out by Mr. Cowper-Coles, yet the "hot-galvanizing" method enables the manufacturer to push the output of his plant to the limit, which fact accounts for the favor which it has always found with our manufacturers. The second method is electroplating of iron surfaces with zinc. As has been pointed out by Prof. C. F. Burgess formerly in this journal, this method gives a decidedly superior and more effective coating. Moreover, much has been done in recent years to facilitate the operation by invention of labor-saving and fool-proof machinery. Both the molten zinc process and the electrolytic process can be carried out now in a practically continuous operation. The third and fourth processes, "sherardizing" and "cowperizing," are comparatively

recent inventions of Mr. Cowper-Coles, and are not yet used commercially in this country, though we may expect their arrival at an early date, since both are not only very interesting, but have distinct advantages for certain work. "Copperizing" is essentially treatment in an atmosphere of zinc vapor. With respect to "sherardizing," Mr. Cowper-Coles emphasizes that the temperature employed is below the evaporating point of zinc (solid zinc). But it appears that the temperature is above the point at which zinc dust, as employed in this method, begins to vaporize. It would, therefore, seem that sherardizing is also to some extent at least a vapor process. The notes on the applicability of sherardizing for decorating and artistic purposes emphasize a point which is already clearly evident. There is little likelihood that any one of the four methods will supersede the others. Each of these will most likely find a field of its own to which it is specially adapted, and all of these together will tend to increase the quantities of iron and steel coated with zinc and to create new purposes for which this is being done.

Ore Dressing

The astounding growth which the art of ore dressing has shown in recent years has been rendered possible by the happy way in which scientific principles have been applied to casual observations made in every-day practice. Ore dressing is a mechanical process with respect to the result, which is separation without chemical change. But the means employed are no longer purely mechanical; they depend no longer on differences of specific gravity only, but use is also made of differences in magnetic permeability, in electric conductivity and in susceptibility to the lifting action of gas bubbles with or without oil. Mr. W. G. Swart's presidential address before the Western Association of Technical Chemists and Metallurgists, printed on another page of this issue, gives a particularly suggestive and concise review of the present situation. We have added some further notes on acid flotation and on the new Elmore oil vacuum process. The latter illustrates well the complexity of many of our modern methods. It is to some extent a combination of a "grease process" with ordinary flotation. Concerning the original discovery of grease processes an anecdote is told which is characteristic whether true or not. At the Kimberley diamond mines a boy was eating his sandwich and a piece of his hunch fell on the traveling belt on which the diamond-bearing clay passed. The belt was thus smeared with butter. The boy was observative enough to note that where the butter was there also were the diamonds. He made easy money in letting his employers into his secret. What Elmore now does is to grease the metallic particles in order to make them more susceptible of attaching gas bubbles; he produces the gas bubbles in a similar way as in ordinary flotation; he increases their lifting effect by producing a vacuum above the liquid; and he makes the whole process continuous.

The Power House of a Large Copper Refinery.

For very good reasons, which we need not discuss at present, the bulk of the large electrolytic copper refining industry of this country is located near New York City. There are the Nichols Copper Works, on Long Island, the American Smelting & Refining Company and the Raritan Copper Works, at

Perth Amboy, N. J., the U. S. Metals Refining Company, in Chrome, N. J., and the Balbach Smelting & Refining Company, in Newark, N. J. We have repeatedly referred to the very important additions which have been made to these works in recent years and which have resulted in doubling the aggregate capacity in about five years. It is with pleasure, therefore, that we publish in this issue a full description by Mr. F. D. Easterbrooks of the new power house of the Raritan Copper Works. It will be found exceedingly interesting in many respects from a constructional point of view, the drawings being particularly instructive. The power house of an electrolytic refinery is a proposition quite different from the ordinary large power house for electric light, power and traction. The characteristic feature of the electrolytic power house is the absolutely uniform load curve throughout the full 24 hours a day. This permits the production of electric energy at a reasonably low rate even with steam power, which is a very important matter, in view of the fact that the power cost is 40 per cent of the whole tank-house cost of copper refining from anode to cathode under present conditions. Figured on the basis of the total cost of refining copper from pig to wire, the power cost is estimated to amount to approximately 22 to 24 per cent of the total cost. These figures refer to the usual multiple system of refining.

Achievements and Technical Possibilities of Photochemistry.

Treated and looked upon in many respects as a veritable step-child of chemistry, photochemistry can boast of one single big technical achievement. Photography is a great art, especially now with the rapid strides made by professionals and amateurs alike in many directions, color photography being not the least interesting development. Yet, when we come down to the rationale of many of the reactions which we employ, we must honestly confess that they are full of mysteries. It is, however, an encouraging sign of the times that just at present we are witnessing a revival of photochemical research. Thus, the German Bunsen Society will have at its coming Vienna meeting a symposium of not less than eight papers on photochemical subjects, while the American Electrochemical Society will listen, at its Albany meeting, to a lecture of Dr. W. D. Bancroft on the electrochemistry of light. This manifestation of renewed interest in an old branch of chemical science is natural enough. The field is wide and almost limitless, and very, very little is known or firmly established. The harvest which will be reaped by the master mind who brings about order out of chaos, will be worth while. Moreover, the subject is not simply one of scientific or theoretical interest. As we intend to show presently, the photochemical reactions which Nature produces indicate technical and commercial possibilities of utmost fundamental importance for human civilization.

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It is not without reason that the present revival of photochemical research is chiefly due to the endeavor of electrochemists. There is indisputable evidence that there must be a close interrelation between photochemistry and electrochemistry. We know that light rays, heat rays, the Hertzian rays employed in wireless telegraphy are all special cases of one and the same

kind of waves—electromagnetic waves. They all obey exactly the same typical laws and they only differ in one respect—the wave-length. Naturally the wave-length is important, and the only fundamental photochemical law which we know with some certainty to be true, states that only light of a color or wave-length can produce a photochemical reaction in a system, if the latter absorbs this special color or wave-length. This selective absorption of light of a certain wave-length is a very peculiar phenomenon. The preference of one wave-length over all others is often exhibited in a peculiar way by a substance, whatever its quantity or external geometrical form, whatever the temperature and the physical state, whether solid or liquid, or solution, etc. It would seem that something within the substance is “tuned” to the special wave-length and on the basis of the electronic theory we can devise interesting and ingenious pictures or models, though they are still too vague to be made much use of. But so much seems evident that the selective absorption of light and the corresponding photochemical processes are phenomena related in some way to electromagnetic resonance. Further photochemical reactions are in general oxidation and reduction processes and from the analogy with electrolytic processes we can conclude that we have here to do with exchanges of ions or ionic charges or electrons. But these are only general indications, though undoubtedly suggestive of some underlying truth. When we come down, however, to a special reaction, we are all at sea. Even with a reaction, like the change of oxygen into ozone by the silent electric discharge, which has been studied extensively and thoroughly, and is employed commercially, we do not know with certainty whether it is a specific electric effect or a photochemical reaction due to ultra-violet light or both. We do not even know whether we put the question correctly in asking whether it is an electric or a photochemical effect.

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The technical possibilities of photochemical reactions are clearly indicated by the processes performed by Nature. The eye is a photochemical instrument, a sort of actinometer. The effects brought about by sunlight on our earth are to an important extent photochemical. On a small scale we have learned to make use of the photochemical effect of sunlight, as in bleaching, while in the destruction of certain paints we have an undesired effect of sunlight. But one of the most important photochemical effects of sunlight—the dissociation of carbon dioxide in green, live plants with the resulting regeneration of the oxygen content in the atmosphere—is a benefit of immense importance which we derive from sunlight without doing anything for it. We do not understand it. We cannot imitate it. G. Kirchhoff has once said that the object of theoretical physics (and, we may add, chemistry) is to “describe” the facts in as complete and concise a manner as possible. Kirchhoff’s meaning of a “description” cannot be misunderstood since his statement was made in the introduction of his lectures on analytical mechanics, and his method of a complete and concise “description” of mechanical processes consists in the use of differential equations. They describe exactly and concisely what will happen if the starting conditions are given. They describe in the same way what the conditions are with which we must start in order to get a desired result. When we are so far in our understanding of the laws of

Nature within a limited field, one of the chief difficulties is removed which the technical man and engineer has to meet. For we may say that it is the object of the engineer to imitate Nature in as concise and cheap a way as possible. To be able to do this, he must understand how Nature acts. In photochemistry we are still far from this point. We can do nothing at present but experiment and keep on experimenting and keep our eyes and our mind open in observing Nature. It is even quite possible that our present experimental methods of chemistry are too “barbarously destructive” to imitate those subtle, delicate reactions which Nature produces. As Dr. L. Backeland recently remarked, “we might just as well try to imitate the melodious music of a Gounod by firing some dynamite cartridges between the delicate strings of a piano.”

* * *

Yet, the difficulties should not discourage us. We should look at the goal. Let us come back again to the work performed by the sun. We will not speak of the heat the sun gives us, nor of the action of the sun in the evaporation of water from the oceans and the resulting cyclic movement of water passing through evaporation and condensation and placing at our disposal the kinetic energy of rivers and waterfalls. Nor shall we speak of the sunlight of ages ago stored up in our coal deposits. Let us consider simply the one reaction, already referred to, of dissociation of carbon dioxide in green live plants, under the action of sunlight. What happens is this: In all combustion processes, in the commercial burning of fuel, as well as in the respiration process of animals, oxygen from the atmosphere is consumed. The atmosphere gets poorer in oxygen and richer in carbon dioxide. But the green live plants absorb from the atmosphere the carbon dioxide and under the influence of sunlight perform the reverse reaction, the decomposition of the carbon dioxide into carbon (which builds up the tissues of the plants) and oxygen which passes off into the atmosphere. Thus the composition of the atmosphere is kept materially constant. Without the photochemical reaction due to sunlight this would not be the case. It is useful to look at this matter in a “sordid” commercial way. What is this photochemical reaction due to sunlight worth to us in dollars and cents? Prof. R. Luther estimates that the artificial production of the same quantity of oxygen by dissociation of carbon dioxide—as is performed by green vegetation on the earth under the influence of light—would require daily at least 15,000,000,000 hp-hours. If we estimate the cost of one hp-hour as one-fourth cent only, this cost amounts to over \$37,000,000 every day. That is the daily value of a single photochemical reaction of the sun on our earth. It is a pious hope of the illuminating engineers that some day they will be able to imitate the glow worm, which is looked upon as the ideal source of light. Photochemists may with even greater justification strive towards the goal of imitating Nature in its photochemical reactions. When this goal is reached, the effect on human civilization cannot be imagined. Our present lack of ability of carrying out photochemical reactions at will under the influence of sunlight, which is at our disposal in unlimited amount, represents a waste, qualitatively just like the waste of non-developed water powers or non-utilized blast-furnace or coke-oven gases, but a waste of immensely and uncomparatively greater importance.

Albany Meeting of the American Electrochemical Society.

The 7th annual and 13th general meeting of the American Electrochemical Society will be held on Thursday, April 30, Friday, May 1 and Saturday, May 2, in Albany, Troy and Schenectady.

The headquarters will be at the Hotel Ten Eyck, in Albany, N. Y. Members will please register and obtain badges upon their arrival in the lobby of the Hotel Ten Eyck.

Thursday, April 30. The morning session, beginning at 10:30 a. m., will be held in the ballroom of the Hotel Ten Eyck, where the following papers will be read and discussed:

The Construction and Accurate Measurement of Resistances of the Order of 10,000 Megohms. H. L. BRONSON.

The Absorption of the Radioactive Emanations by Cocoanut Charcoal. R. W. BOYLE.

Industrial Applications of Aluminium. E. BLOUGH.

The Nature of the Surface Film formed on Aluminium and Magnesium and the Aluminium-Magnesium Cell. H. T. BARNES and G. W. SHEARER.

Mercury Cathodes in Nitric Acid Solution. J. A. WILKINSON.

Copper Anodes in Chloride Solutions. PAUL DUSHMAN.

Solubility Determinations in Aqueous Alcoholic Solutions. A. SEIDELL.

The Potential of the Nickel Electrode. E. P. SCHOCH.

The annual business meeting will be held in the afternoon, also in the ballroom of the Hotel Ten Eyck, at 2 o'clock, where the report of the board of directors will be presented.

The retiring president, Prof. C. F. BURGESS, will then present his presidential address on the Corrosion of Iron from the Electrochemical Standpoint. This address will be open for discussion.

After this address the following papers will be read and discussed:

Electrochemical Corrosion of the Rochester Steel Conduit. RICHARD H. GAINES.

The Alloying of Iron and Calcium. A. HIRSCH and J. ASHTON.

The Preparation of Calcium Alloys for Aluminothermic Work. O. P. WATTS and J. M. BRECKENRIDGE.

Distillation of Turpentine by Electricity. F. T. SNYDER.

Water Power in the Adirondacks and Forest Preservation. E. R. TAYLOR.

Power for Electrochemical Industries. J. MEYER.

In the evening, at 8 o'clock, Dr. W. D. BANCROFT will deliver a lecture on the Electrochemistry of Light. This will be open for discussion.

After the lecture there will be an informal gathering in the café of the hotel.

Friday, May 1. There will be only one meeting in the morning. This will be held in the lecture hall of Union University, Schenectady. Electric cars will leave the Hotel Ten Eyck, Albany, at 9 a. m., going direct to the place of meeting. The meeting will be called to order at 10 a. m., when Dr. C. P. STEINMETZ will deliver a lecture on Kinetic Molecular Energy.

The following papers will then be read and discussed:

The Heat of Vaporization of Metals and Other Substances. JOS. W. RICHARDS.

Robert Hare's Electric Furnace. C. A. DOREMUS.

Electrochemical Patents. A. B. MARVIN, Jr.

The Electrical Testing of Iron during Annealing. E. E. F. CREIGHTON.

The Synthesis of Hydrocyanic Acid in the Electric Furnace. R. S. HUTTON and E. W. SMITH.

At 1:15 lunch will be served in the restaurant (building No. 80) of the General Electric Co.'s works. The society will be the guests of the company.

The afternoon will be devoted to an inspection of the General Electric Co.'s works. The party will be divided into

groups, which will be conducted by members of the staff of the company, and three hours are available to spend in these world-renowned works.

The train leaves Schenectady at 5:45 for Albany, where an informal dinner will be taken at the Hotel Ten Eyck at 7:30. It is hoped that all members and guests in attendance will be present.

Saturday, May 2. There will be a meeting in the morning, which will be held in the lecture room of the Rensselaer Polytechnic Institute in Troy. The meeting will begin at 9:30 and the following papers will be read and discussed:

Conduction in Electrolytes. L. KAHLENBERG.

The Passage of Direct Current through Electrolytes without the Use of Electrodes. CARL HERING.

Reversed Electrolysis. J. W. TURRENTINE.

The Conversion of Iron Pyrites, FeS₂, into a Magnetic Form. O. L. KOWALKE.

The Electrolytic Refining of Iron. E. F. KERN.

Electrolytic Corrosion of Aluminium Bronze. W. S. ROWLAND.

Further Researches on the Electrolytic Corrosion of the Bronzes. A. T. LINCOLN.

Problems in the Manufacture of Dry Cells. C. F. BURGESS.

Lunch will be taken at the Rensselaer Inn at 1 p. m. The afternoon will be devoted to visits to points of interest in Troy, especially to Gurley's factory for making scientific instruments, the Burden Iron Works, the Earl and Wilson linen factories, the Watervliet Arsenal (open 1 to 4 p. m.), the Duncan Paper Mill of the West Virginia Paper Co., at Mechanicville. (The Hargreaves-Bird electrolytic chlorine plant of this company will not, however, be open to inspection.)

Dr. W. R. Whitney is chairman and Dr. C. F. Lindsay is secretary of the local committee.

Bunsen Society.

The annual meeting of the German Bunsen Society will be held in Vienna from May 29 to 31.

There will be a symposium of papers on photochemistry, by Prof. Luther, Dr. Trautz, Dr. Byk, Prof. Stobbe, Prof. Schaum, Dr. Scheffer, Colonel von Hübl and Prof. Wiesner.

Among other papers to be presented we notice the following: Dr. Hans Goldschmidt on new thermite reactions; Prof. Walter Nernst on the theory of the electric irritation of nerves; Dr. Bechhold on the question whether dyeing is a chemical or a physical process, etc.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From our Special Correspondent.)

Metallurgical Research at the National Physical Laboratory During 1907.

The work undertaken on behalf of the Alloys Research Committee of the Institution of Mechanical Engineers embraces (1) further researches on the alloys of copper and aluminium, in continuation of the eighth report by Dr. Carpenter and Mr. Edwards, and (2) the investigation of other series of aluminium alloys.

Copper Aluminium Alloys: Tensile tests at temperatures up to 500° C. have been carried out on specimens turned from rolled bars containing 9.90 and 6.73 per cent. aluminium, respectively, in the electrically-heated tube furnace described in the report for 1906. In the case of the alloy containing 9.9 per cent. aluminium there was steady decrease of tenacity as temperature increased. Strength was fairly maintained up to 350° C., but above 400° C. weakness developed rapidly. The elongations were rather erratic, but indicated increased elongation with rising temperature. With the alloy containing 6.73 per cent. aluminium, tensile strength fell regularly with in-

creasing temperature, and more rapidly above 400° C., but in contrast with the first alloy, this showed a marked and regular decrease of elongation with increase of temperature. This is in accordance with these alloys having been placed in different groups in the 1906 report.

Sea-water corrosion tests are being carried out at Portsmouth Dockyard on specimens of copper-aluminium alloys, naval brass and Muntz's metal. After machining, some specimens were framed in teak and some were bolted onto mild steel plates. The first are free from galvanic action; the second are so disposed that action occurs only with the steel on which each specimen is secured. As it appears possible that the relative position of the alloys will not be the same on a prolonged test as on a short immersion, these tests will be continued for some time.

Further Series of Aluminium Alloys: Investigation of ternary alloys of aluminium with copper and one other element, e. g., manganese, zinc and nickel, has been undertaken, and a preliminary exploration of the mechanical properties of the manganese series has been nearly completed. The results cannot be stated at present, except that the mechanical properties of copper-rich alloys of aluminium and copper can probably be decidedly improved by additions of small proportions of manganese. The difficulties incident to the use of approximately pure manganese have led to experiments with a view to using a definite copper-manganese alloy obtainable commercially. The micro-structure of the preliminary alloys has been studied, but their thermal study by means of cooling curves, quenching, etc., is reserved until the constitution of the alloys of aluminium and manganese shall be better understood. A large number of aluminium-manganese alloys have been prepared for study of freezing points and cooling curves, but difficulty has arisen from the fact that the manganese available is only 97 to 98 per cent. pure, aluminium, silicon, iron and carbon being present. As it is possible that certain of the critical points of the alloys near the manganese end of the series may be wholly or partly due to these impurities, the preparation of a pure manganese-aluminium alloy containing as high a proportion of manganese as possible has been attempted, but the requisite degree of purity was not attained, although better results are anticipated from the use of purer aluminium. By means of such an alloy to which successive additions of aluminium may be made to obtain alloys with less manganese, the more important observations on the freezing and cooling curves will be repeated, so that for these members of the series the influence of impurities will be eliminated.

For alloys ranging from pure manganese down to the specially prepared pure alloy, this elimination of impurities will be difficult, and the determination of the freezing point of pure manganese, especially, must be carried out by other methods than those adopted for the ordinary metals and alloys. It is noteworthy that alloys lying near the manganese end of the series attack porcelain and fire-clay very rapidly, and thermo-junction protectors made of these substances are destroyed in a few minutes when immersed in the fluid metal. Tubes of pure magnesia have, therefore, been used, but they cannot be withdrawn from the molten metal without fracture. The study of the aluminium-manganese alloys already promises interesting results. Those containing between 65 and 30 per cent. of manganese are remarkable for their disintegrating spontaneously, and more or less rapidly, from the solid cast state into fine crystalline powder. The nature of the change causing this phenomenon is under investigation. The micro-structure of these alloys has also been studied, both when slowly cooled and when quenched from definite temperatures suggested by the cooling curves. The method of quenching consists in heating the specimen in a tube of vitreous silica from which the air has been pumped as completely as possible and which passes through the porcelain tube of an electric tube furnace without contact. Water is driven by atmospheric pressure into the exhausted tube, and the rapidity of cooling in this way appears to be considerably greater than that obtained by simple immersion of the

specimen in water, and approximates to that obtained by vigorous agitation of a specimen in cold water. The silica tubes appear to be unaffected by this treatment up to higher temperatures than 800° C.

Cooling Curve Research: The results obtained have been embodied in a paper read before the Physical Society of London, on Jan. 24, 1908. The general conclusion arrived at is that both the differential method and the direct method (the observation of time and temperature during the cooling plotted as inverse-rate curves) are capable of yielding delicate and accurate curves, but that the direct method requires much more delicate apparatus than the differential to obtain the same degree of accuracy. The effect of various rates of cooling, varying from one hour and three-quarters to twelve minutes for a range of 400° C., upon the form of the differential cooling curves has been tried, and it was found that these as ordinarily plotted were difficult to interpret when the rates of cooling were rapid, owing probably to the differences of temperature set up between the two bodies under comparison becoming great as compared with their rate of change at or near recalescence points. A "derived differential" curve, representing the differential coefficient of the ordinary differential curve with respect to temperature was, therefore, plotted. It bears to the ordinary differential curve a similar relation to that existing between the simple "time temperature" curve and the "inverse-rate" curve, and it greatly facilitates correct interpretation—the curves thus obtained for widely different rates of cooling showing a remarkable agreement. It has further been shown that the interpretation of the indications of cooling curves in terms of the quantity of heat evolved at a given recalescence is only possible, even to a rough approximation, when the rate of cooling of the body under observation has remained constant during the various recalescences to be compared. The experimental work of this research revealed a well-marked recalescence in crystalline silica at 580° C. Recalescence was observed in an electric-resistance furnace in which blank differential curves for a pair of platinum cylinders were determined. It was traced to the quartz packing of the furnace, and was found to exist in all the porcelains containing free silica, but not in those containing an excess of alumina, in which there was no free silica. Silver sand gave the recalescence at 580° C. in a very marked manner, both on heating and cooling, while amorphous silica (precipitated) and vitreous silica (fused quartz) were entirely free from reaction. Consequently the recalescence appears to be due to a polymorphic change in the crystalline silica; and there is a probability that a series of recalescence points at and just below 600° C. shown in cooling curves of steel published by Roberts-Austen, Carpenter and Keeling, and others should be referred to the silicious materials of the furnaces and not to the steel.

Eutectics Research: The lead-tin eutectic was prepared in a state approaching purity without difficulty, and its structure and behavior studied in detail. It was found that the view of Roberts-Austen and others that tin was only very slightly soluble in solid lead, was due to insufficient time having been allowed for the alloy to attain a condition of equilibrium. The alloys appear to require exposure to a temperature of about 175° C. for several weeks to attain complete homogeneity in the solid lead-tin solution. The exact limit of solid solubility at this end of the series has not been determined, but probably lies near 17 per cent. of tin. There is a well-marked recalescence in alloys lying between 5 and 40 per cent. of tin. In alloys between 18 and 40 per cent. this occurs on cooling at a constant temperature of 145° C., but below 18 per cent. the temperature of recalescence on cooling falls rapidly until at 5 per cent. it lies very near the ordinary temperature. For polishing, very soft alloys rich in lead oxide of chromium, obtained by calcination of ammonium bichromate and subsequent levigation in slightly ammoniacal water, are used, as recommended by Le Chatelier. The Zeiss apparatus for obtaining photo-micrographs by ultra violet light has been installed. It consists of a

microscope and vertical camera so placed that the camera can be readily swung aside. The microscope has objectives of 6 mm and 1.7 mm focus of vitreous silica, while the eye-pieces and illuminating train are of rock-crystal. The light is derived from a spark between magnesium or cadmium electrodes, excited by means of a large induction coil with a mechanical interrupter and a battery of seven Leyden jars in parallel. This arrangement gives a short, thick spark with a large proportion of ultra-violet light of wave-length $.275 \mu$. In the apparatus of Messrs. Zeiss the light passes through a train of two 60° quartz prisms, and in the arrangement first tried in the laboratory the spectrum image of the spark was focussed upon the aperture of the vertical illuminator. In the apparatus devised by Dr. Kochler the image formed by the microscope is observed and focussed approximately by means of a searcher eye-piece provided with a screen of fluorescent uranium glass and a viewing eye-piece, and when the image appears in focus in the searcher it should also be in focus on the screen at a definite camera extension. Focussing was found to be very difficult.

Some sharp photographs with a magnification of about 400 diameters were obtained after much trouble, with the 6 mm objective, but with the more powerful lens and the high magnification which should constitute the principal value of this apparatus no satisfactory results could be obtained. Monochromatic blue light was then tried for finding the best arrangement of illumination for the avoidance of internal reflections, finding the required spot on the specimen, and finding the approximate focus. A small arc lamp gives a spectrum by means of a small optical bench provided with a prism and Thorp grating, and the spectrum is brought to a focus on a screen in which a small circular aperture allows a pencil of light of the desired wave-length to pass towards the aperture of the microscope. With due adjustment and further concentration of the light by a short-focus condenser just outside the illuminator aperture, an even, brilliant illumination of the field of the quartz objectives can be obtained, and an image which, with moderate eye-piece magnification, leaves nothing to be desired as regards definition. In the final arrangement it is intended to adjust matters so that by the insertion or removal of a small mirror the beam of light from the arc lamp can be instantly replaced by a beam of ultra-violet light from the spark-gap. It is found that the monochromatic blue image can be focussed satisfactorily on a transparent glass screen, by aid of a focussing glass, at a magnification of 1,000 diameters. It is then intended to calculate from the known difference of wave-length the change in focus required to bring the ultra-violet image into register. In order to reach the highest useful powers of these lenses, viz., 3,600 diameters, the image obtained on a fine-grained photographic plate at 1,000 diameters is to be enlarged in the ordinary way three and a half times.

Metallurgical Test Work.

There has been a very considerable increase in the amount of test work as compared with the past two years. It comprised two enquiries, jointly with the engineering department, into causes of failure of large steel objects; one investigation of steel rails for the Great Northern Railway; three type-metal enquiries; two of hardening of steel, and one of corrosion of brass. Photo-micrographic work was also carried out.

The features of these enquiries, which are of general interest, are as follows:

Failure of Large Steel Objects: Chemical analysis and microscopic examination were resorted to. In both cases the microscopic indications were sufficiently clear to allow of a definite conclusion being drawn. In one case failure was due to the steel being contaminated to an undue extent with enclosures of "slag" (probably silicate and sulphide of manganese). These are always present in commercial steel to some extent, but become a serious source of weakness when excessive. In this case the enclosures were never missing from a single field of view, even with magnifications of 150 diameters, when specimens several square inches in area were completely

searched. The material in question being subjected to extremely severe treatment, the microscope showed it to be fissured between adjacent enclosures. In the second case no serious defect in the structure of the mass of the steel was revealed, the only undesirable feature being the occurrence of some "ghosts" and other signs of segregation on a very small scale. Further examination of the material near the fracture proved that the metal had been subjected to very severe local deformation, and the nature and severity of this are regarded as sufficiently accounting for the failure.

The investigation of steel rails for the Great Northern Railway Company included a complete study of the microstructure, hardness and mechanical properties of various rails, some of which had been in prolonged use, and some were of novel composition or character. One rail which had been in use for 35 years proved to be low in carbon, but higher in phosphorus than most modern specifications would permit. The high proportion of phosphorus may have enabled the rail to withstand wear longer than a low-phosphorus rail of the same low carbon content and microstructure could have done, but this rail would probably not have lasted so well as the better modern rails under the present heavy main line traffic. The new rails varied so very widely in quality, as indicated by mechanical tests and microstructure, that they could not be classified. It will be interesting to follow the history of such of these types of rails as may be put into service, with a view of ascertaining how far the indications of tests may be relied on as predicting the service value of the rails. The method of "sulphur-printing" was used to test the distribution of sulphur in the cross-sections of the rails. It consisted in laying upon the smoothed surface of the rail section a sheet of bromide paper previously soaked for a short time in a 10 per cent. solution of sulphuric acid. Sulphuretted hydrogen is evolved wherever the acid in the paper comes into contact with a sulphide patch in the steel, and a corresponding patch of silver sulphide is formed on the paper, and thus the relative darkening of the various parts of the paper indicates the distribution of sulphur. The Great Northern Railway rails showed few signs of marked segregation.

Type Metal: In two cases the investigations included determinations of melting and freezing points, microstructure and chemical composition. The third enquiry related to a systematic investigation of type-metal in general with a view to improvement of manufacture. Unfortunately the laboratory was not able to continue the work under the conditions proposed by the firm. This is to be regretted, as the work already done gave much promise of valuable results.

Hardening of Steel: Specimens of steel hardened to various degrees by the aid of Messrs. Taylor, Taylor & Hobson's patent magnetic indicator for hardening steel were submitted to the laboratory, and after these had been reported on, that firm sent a small muffle furnace fitted with their patent indicator for trial. Subsequently they even presented the apparatus to the Laboratory, where it has proved useful for the occasional hardening of small tools. A person accustomed to the use of this indicator would, with normal varieties of tool steel (not high-speed or special steels), attain a very considerable degree of uniformity in hardening. In connection with his experiments on the distortion of steel during hardening, Colonel Crompton sent a number of enquiries to the Laboratory.

Corrosion of Brass: Some condenser pump rods which had broken after a relatively short period of use in seawater were examined. The microscope revealed that the brass had been vigorously attacked, the greater part of the zinc having been removed, leaving a mere spongy mass of more or less oxidized copper.

Market Prices During February and March.

During February the following prices prevailed:

Tin:—Opened at £125 per ton and rose sharply to £130 by the 4th, there were some variations until the 13th, followed by a fall

to £126 10 0 on the 18th, and a sharp rise to £131 on the 21st, the price then fell with some variations to £129 on the 29th.

English Lead:—Opened at about £15 4 0 per ton, and fell steadily during the month, reaching £14 2 0 on the 27th, the price rose slightly to £14 8 0 on the 29th.

Copper:—Opened at £61 per ton, rose to £62 on the 5th, and fell steadily to £56 15 0 on the 19th. It then rose to £58 8 0 on the 21st, and after slight variations reached about £57 10 0 on the 29th.

Hematite:—Opened at 58/10 and, with the exception of a rise to 59/- on the 5th and 7th, remained at this figure until the 19th when it rose to 59/2, remaining at this until the 25th it rose to 60/6 on the 28th, and fell from this slightly on the 29th.

Cleveland Pig:—Opened at 47/6 and rose with slight irregularities to 50, 10 on the 26th, fell to 50/- on the 27th, and closed at 50/6.

Scotch Pig:—Opened at 56/-, rose to 56/6 on the 5th and 7th, and remained at 50/- until the 14th when it commenced to rise and reached 57/- by the 26th. It closed at 56/8.

The prices of chemicals at the end of February were as follows:

Ammonia sulphate, f.o.b. Liverpool.....	£12 2 6	per ton.
Copper sulphate	24 0 0	"
Caustic soda, white 77 per cent.....	11 2 6	"
Bleaching powder, 35 per cent.....	4 10 0	"
Carbolic acid liquid, 97/99 per cent.....	1 1	per gal.
Creosote, ordinary good liquid.....	2 3/4	"
Naphtha solvent, 90 per cent., at 160° C., f.o.b.	10 0	"

Shellac, standard T. N., orange spots..... 6 2 6 per cwt.
Antimony, Star Regulus, f.o.b..... £34 to £35 per ton

The general tone of the metal market during March has been steady. Cleveland pig iron has risen throughout the month, closing at 52/- per ton. Copper showed an upward tendency during buying, but has since settled to £60. Electrolytic is quoted in sheets at £79 per ton. Block tin has risen to £142 10 0 to £143 10 0 per ton. Ingot and sheet lead shows slightly higher at £14 10 0 to £14 15 0 per ton. Zinc sheets are £25 10 0 per ton. Brass tubes (brazed) are at 9d per pound. Platinum is quoted at 100/- per ounce, and aluminium at £106 5 0 per ton, in ingots.

Hematite, after a sharp rise on the 31d of the month, remained fairly steady, finishing at 62/-.

Chemicals remain much at the same prices. Ammonia sulphate, f.o.b. Liverpool, £12 5 0 per ton.

Copper sulphate.....	£25 0 0
Caustic soda (48 per cent.).....	5 10 0
Bleaching powder (35 per cent.).....	4 10 0
Shellac, ordinary, per cwt.....	5 0 0
Para rubber, slight decline to.....	3 2 1/2 per lb.
Gutta percha.....	5 6 to 6 6

The Iron and Steel Market.

The pig iron markets have shown a very slight decline during April, while the prices of finished steel products have been held rigidly, in accordance with the policy formulated immediately after the decline in activity last October.

The total tonnage output in April was substantially the same as in March, but there was a slight decrease in new business, rather than an increase, which seems to presage slightly lower production in May and June. The general opinion expressed by steel interests, however, is that production will remain substantially unchanged until July, when the usual slackening will occur. Mills will close much more generally than usual for repairs in midsummer. Hopes are entertained that after the presidential nominations are made and crops assured there will be some improvement in orders.

No definite policy as to prices of finished steel products has been outlined in the public utterances of steel manufacturers other than that they should be just and reasonable at all times and that for the present no change is contemplated. Some

observers profess to be convinced that a general reduction will be made by the middle of June, the reductions being timed so as to give the market a chance to become settled before the usual fall buying period.

THE RATE OF PRODUCTION.

The rate of pig iron production increased in February over January, and in March over February, the March output being substantially the same as the December output. Since March there has been a slight declining tendency. The rate in the first four months of the year has been a trifle less than one-half the rate maintained last October, when the industry reached its zenith of productive activity, yet it has been slightly in excess of the rate during the phenomenal boom year of 1899, illustrating forcibly how productive capacity has increased in less than a decade.

The production of coke in the upper and lower Connellsville regions in the first four months of this year has been just a shade under 40 per cent of the production in the corresponding months last year, although the number of ovens has increased 12 or 13 per cent. The average furnace activity has been greater than Connellsville coke activity partly because furnaces having local ores and coke have done better than those depending on Connellsville coke and Lake Superior ores.

The output of finished steel has hardly been as great, relatively, as the output of pig iron, and has probably been at the rate, in the four months of this year, of about 40 per cent of the rate last October. The difference is accounted for partly by the accumulation of stocks of pig iron, some estimates, apparently based on good information, placing the pig iron stocks at more than a million tons.

At present the most active lines are tin plates and wire products; the moderately active are sheets and structural shapes, while the least active are pipe, rails, merchant bars and plates.

Tin plate production is substantially normal, and is likely to be maintained so until about the end of June, when it invariably declines. The leading interest is operating 202 tin mills; it has a total of 242 tin mills, but the bulk of the idle ones have not operated for two or three years. Almost all the independent tin mills are running full, and the current output is at least 95 per cent as great as ever reached. Tin plates normally constitute about 3.3 per cent of the total finished steel output.

The wire mills have been running at about 75 per cent normal, but stocks have been accumulated in jobbers' and retailers' hands, consumers not buying at the same rate the material has been produced, and somewhat lessened production is promised this month.

Sheet production has steadily increased and is now between 50 and 60 per cent of the maximum; current orders are at about the production rate, and neither an increase nor a decrease in output is promised for the next two months.

Structural business has been stimulated by the greatly reduced prices named by fabricating interests, whereby they seem to have given away about all their intermediate profit and have even been suspected, probably erroneously, of securing concessions on the mill shapes. The contract of the Corn Products Company, in the Chicago district, for instance, went at a flat price of \$44 a net ton, delivered, there being 3,600 tons of fabricated work and 600 tons of castings. Prices of fabricated material have declined \$10 to \$15 a ton from last year, while there has been no open change in structural shapes since the advance of August 31, 1905. Most of the structural mills are running to part capacity, and current output is probably more than 50 per cent of normal.

Business in steel pipe is diminishing. Present prices have been guaranteed to May 15 and jobbers, now that they have had an opportunity to dispose of their stocks, are anxious to see a reduction, as the present price basis is seven points, or about \$14 a net ton, above the basis ruling at the beginning of 1906. Other steel products have been advanced relatively little during that period.

The rail trade is unsatisfactory, partly on account of the poor

financial condition of the railroads and partly on account of the difficulty over specifications. Based on the track mileage of the roads which have formulated their requirements for the year it has been estimated that standard rail business may not be more than 30 per cent the average of the past two years, but the reads may, of course, come in with additional requirements later.

The Pennsylvania Railroad Company has made public the specifications which accompanied the orders for 55,000 tons which were formally tendered the rail mills on February 6 and refused. The most objectionable features are that if a rail breaks under test without showing physical defect the entire heat is summarily rejected; that if it does not break, but on testing to destruction shows pipe, the top rails of the heat shall be rejected, and that "no rails shall be accepted which contain any physical defects that impair their strength," while there are more stringent requirements as to the amount of straightening permissible in the cold straightening presses. It is not permitted to hold the piece, or use artificial means of cooling, from the leading pass to the hot saws, and the shrinkage allowance is a trifle less than that in former practice, requiring finishing at a slightly lower temperature. The matter of rail specifications seems now to have developed into a contest of endurance between the railroads and the rail mills, the railroads having this advantage that they would not be disposed to buy rails freely in any event.

Merchant bars are inactive, and are suffering from the competition of bars rolled from old steel rails. A price as low as \$1.75, delivered, has been made on reinforcing bars for concrete, made from old rails, while steel bars are \$1.60, base, Pittsburgh. The season cotton tie price was announced in April, at 85 cents a bundle, 10 cents less than the 1907 price, and the same as ruled in 1905 and 1906. Plates are probably the dullest item in the list, as the steel car business is all finished and there is no prospect of further buying for the present.

Iron bars are being shaded more than formerly, particularly in the East. The recognized market is \$1.50, Pittsburgh, for Pittsburgh or Eastern delivery, and \$1.47, Pittsburgh, for Western delivery. Steel prices are being shaded occasionally in some lines. Delivered prices on billets and sheet bars have been revised, but the base, Pittsburgh, remains unaltered. With a few exceptions delivered prices are the base prices of \$28 on billets and \$29 on sheet bars, plus one-half the freight from Pittsburgh to point of delivery, but for actual Pittsburgh delivery billets are \$28 and sheet bars \$29.50. The regular official prices on finished steel products remain as follows:

Beam and channel, 15-inch and under, \$1.70.
Plates, tank quality, \$1.70.
Steel bars, \$1.60, base, half extras.
Wire nails, \$2.05, base.
Sheets, 28 gauge, \$2.50.
Tin plates, 100-lb. cokes, \$3.70.

The Outcome of the Bearing Metal Alloy Suit.

The Ajax Metal Co., of Philadelphia, in their suit against the Brady Brass Co., of Jersey City, N. J., had formerly obtained a decision from the Circuit Court of the United States for the District of New Jersey sustaining the validity of patent 655,402 (owned by the Ajax Metal Co.) and finding infringement by the Brady Brass Co.

This decree of the lower court has now been reversed by the United States Circuit Court of Appeals for the Third Circuit, and patent 655,402 of the Ajax Metal Co. has been found invalid. The decision was rendered by Judge Gray.

The patent in question is a product patent for a bearing metal containing "less than 7 per cent tin and more than 20 per cent lead and the balance copper." Before this patent was applied for, it was known in the trade that the quality of the bearing metal would be improved by increasing the amount of lead and that it was necessary for this purpose to reduce

the tin. The selection of less than 7 per cent tin and more than 20 per cent lead is considered a mere change in proportions toward which the state of the art was already drifting, and which therefore did not involve an act of invention or introduce any changes other than those already in progress in the normal development of the art. Satisfactory evidence was also produced that such an alloy had successfully been made by the Brady Brass Co. The decision concludes that "a mere advance in the proportions of the constituents of an alloy, however useful the result may be, does not entitle the originator to the monopoly of a patent, in the absence of other circumstances, than those here disclosed."

Exhibition of Safety Devices.

The exhibition at the Museum of Safety Devices, 231 West Thirty-ninth Street, New York, was formally opened on April 11. Speeches were made by Mr. Walter C. Kerr, Prof. F. R. Hutton, Dr. W. H. Tolman, Dr. Josiah Strong, Prof. C. E. Lucke and Mr. Charles Kirchhoff.

While many of the exhibits relate to the prevention of railway accidents, the exhibition is of general and diversified interest. The United States Steel Corporation is planning an exhibit of steel props for coal mines. They will be shown in a full-sized model of a coal shaft. The appearance of the interior will be simulated in papier-mâché, and a miner will be at work to make the exhibit more realistic.

CORRESPONDENCE.

Transvaal Rock Drill Competition.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—As you will see from the following notice, the Transvaal Government and my Chamber are initiating a stope drill competition which will be held in the early part of next year. It is desired to give this fact the widest publicity in order that drill manufacturers in America, as well as in other countries, may be afforded the opportunity of taking part in the competition.

TRANSVAAL CHAMBER OF MINES (Johannesburg),
LONDON, March, 1908.

A. N. GOLDRING, *London Secretary.*

TRANSVAAL STOPE DRILL COMPETITION.

The Transvaal Government, in co-operation with the Transvaal Chamber of Mines, has arranged for a practical trial of small rock drills suitable for narrow stoping work under the working conditions obtaining on the Witwatersrand.

All types of rock drill are eligible to compete. Drills using compressed air will be supplied with a pressure varying from 60 to 75 lb. per square inch at the working face. The mining regulations require the provision of dust-allaying appliances, and competitors must make provision accordingly.

Two prizes, of £4,000 and £1,000, respectively, are offered. The trials and the judging will be so arranged as to decide which machine performs the most economical work.

The competition will commence early in 1909, and entries will probably close with the end of 1908. The trials will last about six months, the drills being tested in the first instance on the surface and those considered suitable being given a more prolonged test under ground in several stopes in various mines on the Witwatersrand.

The detailed conditions governing the competition, including the exact date of closing entries, will be published as soon as possible.

All enquiries should be addressed either to the secretary, Stope Drill Competition, Transvaal Chamber of Mines, Johannesburg, Transvaal, or to the London secretary, Transvaal Chamber of Mines, 202, 203 and 206 Salisbury House, Finsbury Circus, London, E. C., England.

The Power Plant of the New Addition of the Raritan Copper Works.

BY FRANK D. EASTERBROOKS.

With the increased production of copper at the mines and smelters came the necessity for additional refining capacity. The Raritan Copper Works (for a description of the original plant see the article by Lawrence Addicks, *Mineral Industry*, Vol. IX, 1901, page 261), designed and built by its manager and superintendent, Mr. J. C. McCoy, had a maximum monthly tank house production of 13,000,000 to 14,000,000 pounds of cathode copper. The new plant, representing in its construction the best modern engineering practice applied to electrolytic

and weighed, it is unloaded in the yard storage with a Gantry crane, thus releasing these cars for further use.

A new coal trestle of 5,000 tons capacity has been constructed close to and parallel with the power house. That portion opposite the boiler room is used for storing anthracite coal for the boilers, while on the rest of the trestle bituminous coal, coke, pyrites, etc., for the copper furnaces are stored. Electric cars running on tracks under the concrete floor of the storage are used to transfer the material to the furnaces.

For fire protection all of the buildings, with the exception of the furnace buildings and No. 2 power house, are equipped with an automatic sprinkler system. Two separate brick buildings house the 1,500-gallon and two 1,000-gallon per minute underwriter pumps, which are always ready for immediate use, while

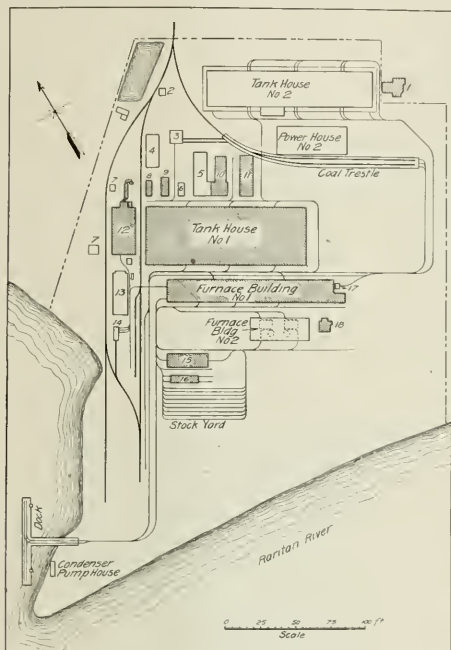


FIG. 1.—PLAN OF RARITAN COPPER WORKS.

- | | |
|-------------------|-----------------------|
| 1. Office | 10. Cupel house |
| 2. Oil Storage | 11. Sulphate building |
| 3. Foundry | 12. Power house No. 1 |
| 4. Machine Shop | 13. Coal storage |
| 5. Parting plant | 14. Engine house |
| 6. Smithy | 15. Storage building |
| 7. Fire pumps | 16. Sampling |
| 8. Carpenter shop | 17. Elevator |
| 9. Stores | 18. Blast Furnace |

refining, was designed and built by Mr. George K. Fischer, consulting engineer of the company, under the immediate direction of Mr. D. J. Nevill, member Amer. Soc. Mechanical Engineers, and has a maximum output approximately the same as the old plant.

On the accompanying plan (Fig. 1) is shown the general arrangement of the entire works, the shaded portion representing the old part.

The system of narrow-gauge tracks has been extended throughout the entire plant, three Porter locomotives and a large number of 10-ton flat cars being used to transfer the material. A standard-gauge switching engine is part of the equipment. Incoming copper is unloaded from freight cars by air hoists onto the small steel-frame cars of the narrow gauge system. If not required for immediate use, after being sampled

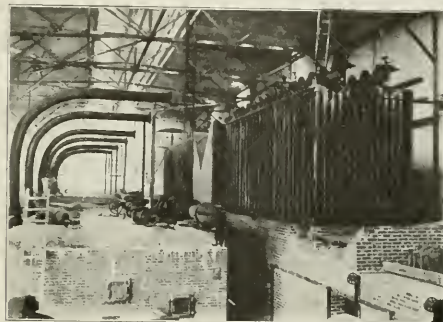


FIG. 2.—GENERAL VIEW ON TOP OF BOILERS, SHOWING FLUES AND TWO ECONOMIZERS.

a 100-gallon pump is used to maintain a constant pressure on the lines. A 500,000-gallon reservoir and a number of hose houses situated at convenient points form a part of the protective system, which includes also a finely organized fire department.

Power House, No. 2.—This building, in which are located the electrolytic generating units for the No. 2 tank house,



FIG. 3.—ANOTHER VIEW OF ENGINE ROOM.
(Note the massive foundations.)

the air compressor, and all the light and power generating units for the entire plant, is 260 ft. long by 106 ft. wide. It is a steel-frame structure with concrete foundation and brick walls. On top of the fireproof roof, which was constructed by the Metropolitan Fire Proofing Company, is a five-ply tar and slag roof. A brick wall running lengthwise of the building separates the engine room from the boiler room. The rein-

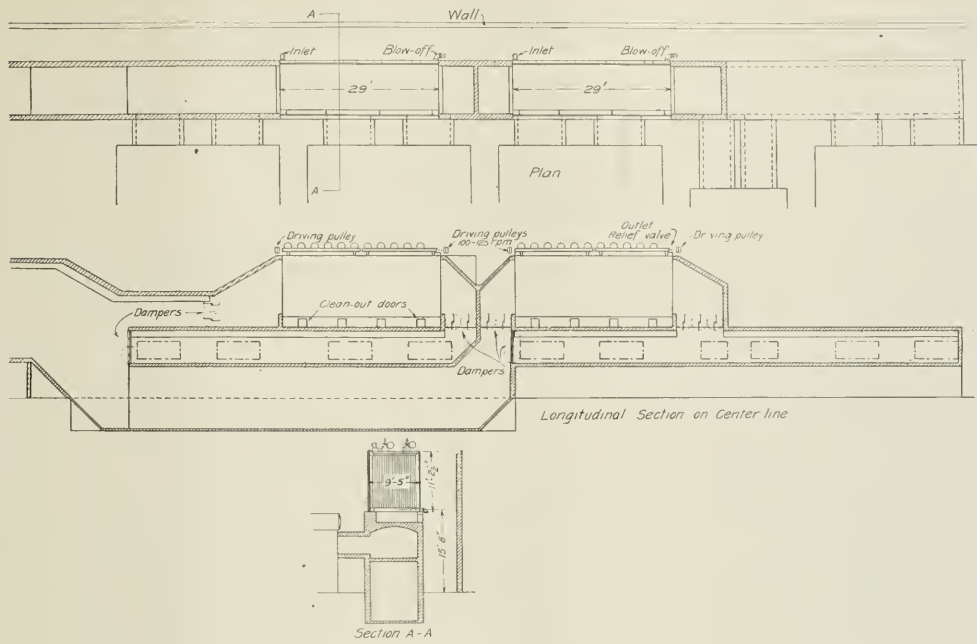


FIG. 6.—FLUES AND ECONOMIZERS.

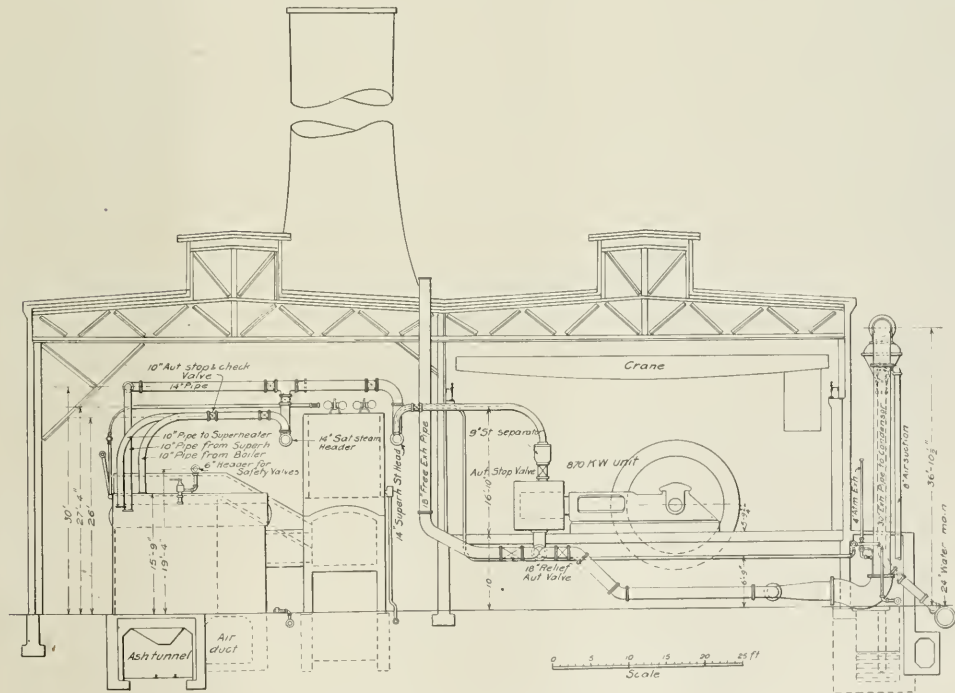


FIG. 7.—SECTION THROUGH POWER HOUSE.

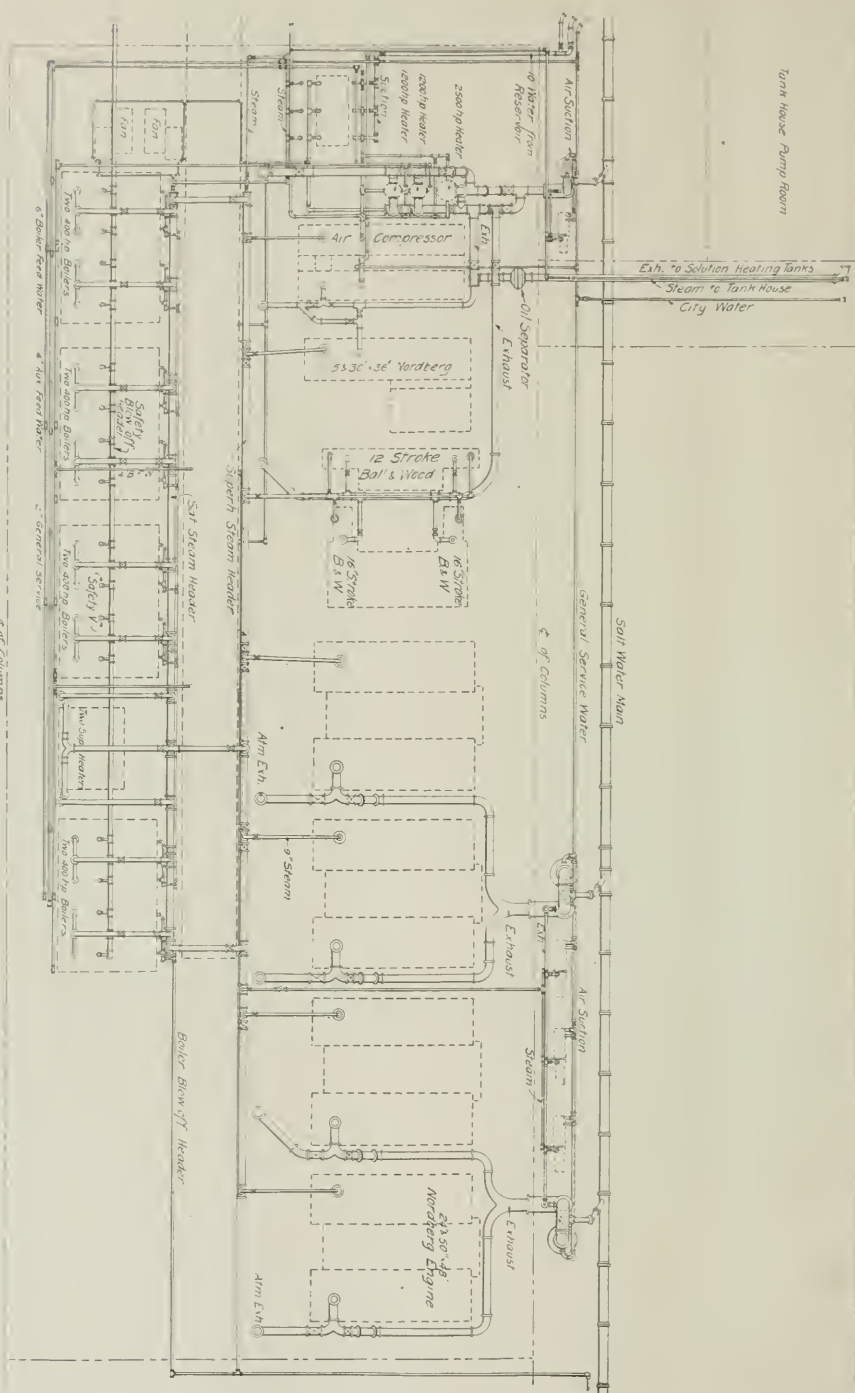


FIG. 8.—GENERAL PLAN OF PIPING.

4 of Columns

Engine Room.—For furnishing power to the three electrolytic circuits in the tank house there are four 24 in. x 50 in. x 48 in. horizontal cross-compound Nordberg engines especially designed for heavy duty, driving 870-kw General Electric generators. One unit, held in reserve, is connected to run on any of the tank-house circuits. These engines have Corliss valve gear, run at 100 r.p.m. and are guaranteed an economy at full load of 11.4 lb. of steam per i.h.p. with 150 lb. steam pressure at the throttle, 100 deg. F. superheat, and 28 in. vacuum. They are provided with Locke engine stops. The individual switchboards and switches were constructed by the Walker Electric Company. Two switches in parallel have a capacity for the full overload of 7500 to 8000 amperes. Eppensteiner engine stop relays, manufactured by the Weston Electric Company, are in use on the switchboards. This relay, which was worked out at the plant of the U. S. Metals Refining Company (see article by Addicks, *Eng. and Min. Jour.*, May 25, 1907), is a valuable protective device for electrolytic circuits. It is connected to the ammeter shunt and in the event of an overload operates the engine stop and shuts down the engine.

For furnishing light and power to the entire plant there are four Ball and Wood horizontal, tandem-compound, high-speed units, two direct-connected to 75-kw generators and two driving 175-kw General Electric generators, which were transferred from No. 1 Power House, and a 15-in. x 30-in. x 36-in. horizontal cross-compound Nordberg engine running at 110 r.p.m. and driving a 275-kw General Electric generator. These units all operate in parallel at 240 volts direct current. The distribution of power to the various departments is controlled from a main switchboard, which was furnished by the Walker Electric Company, and is equipped with Weston instruments and I. T. E. circuit-breakers of the Cutter Company.

A Nordberg horizontal, cross-compound two-stage air compressor 13-in. x 20-in. x 36-in. stroke at the steam end and 14.25-in. x 23-in. x 36-in. at the air end, with a capacity of 1500 cu. ft. of free air per minute furnishes air for the numerous uses around the plant. This compressor has an economy of 11.5 lb. of steam per indicated hp running at 87.5 r.p.m.

Piping.—The general plan of the piping is shown in Fig. 8. Normally feed-water is taken from artesian wells sunk on the premises, the water being pumped into the reservoir by compressed air. Three Blake compound outside-packed plunger pumps 8-in. x 7-in. x 12-in. force the water through the closed heaters, and the economizers into the boilers. An auxiliary feed line takes water from the city water company. The three closed heaters, made by the Goubert Manufacturing Company, are connected so that any or all can be readily by-passed if found necessary for any cause. A Venturi water meter, with self-registering device, measures the water feed to the boilers. A separate supply line running to the boilers furnishes water for washing down, testing, etc.

Long-radius pipe bends and extra heavy welded steel flanges were used throughout. All of the valves used on the main steam lines are of the gate type, furnished by Best & Company, with the exception of the automatic stop and check valves installed on the boilers, which were furnished by the New Bedford Boiler & Machine Company. The steam lines are suspended simply by turn-buckle rods, hung from trussed beams, resting on the roof trusses of the building. Two Foster superheaters, separately fired and located in a line with the boilers, are used to superheat the steam. Each one is capable of superheating 48,000 lb. of steam per hour 125 deg. F. The duplicate steam mains with their cross-connections enable any of the engines to be run on either saturated or superheated steam. Provision is made through a proper arrangement of pipes and valves for frequent economy tests of both boilers and engines.

The exhausts from the engines running on the electrolytic circuits pass into two Worthington elevated jet condensers, one 30-in. condenser being connected to the exhausts from two engines. Three dry-air pumps, each 10-in. x 18-in. x 18-in.,

are connected to these two condensers. Condensing water is supplied to both power houses by three 15-in. R. D. Wood centrifugal pumps direct-connected to motors which are located near the river in a separate building.

The light and power engines and the air compressor are arranged to be run condensing or on back pressure, the exhaust steam being used to heat the tank-house electrolyte. The exhausts connect to an 18-in. jet condenser, to which is connected a 6-in. x 12-in. x 12-in. dry-air pump.

The usual gravity return system is used for circulating the lubricating oil.

The following table gives some of the principal features of the two power houses:

	No. 1 Power House.	No. 2 Power House.
Boilers.....	Aultman & Taylor,	Babcock & Wilcox,
Grates.....	Murphy stoker,	McClave hand-fired,
Coal used.....	Bituminous,	Anthracite,
Steam.....	Saturated,	Superheated,
Engines.....	Ball & Wood vertical,	Nordberg horizontal,
Generators.....	Westinghouse and General Electric	
	General Electric,	
Maximum current	5000 amperes.	7500 to 8000 amperes.

ORE DRESSING

With Special Reference to Oil Concentration

An interesting review of the present status of the art of ore dressing was given by Mr. W. G. SWART in his recent presidential address before the Western Association of Technical Chemists and Metallurgists. The address is printed in full in the March issue of the *Western Chemist and Metallurgist*.

In mechanical separation the operator is brought in every instance early and squarely against the slime or dust problem and "to-day there is no successful method of handling either for purposes of separation." But along the line of separating particles of medium fineness considerable progress has been made.

As to wet concentration Mr. Swart suggested three different lines of work as promising.

First, the use of hot water, which is said to have already attained some considerable degree of success.

Second, the use of alkaline or saponaceous material in the mill water to aid in the rapid settlement of slimes, in the clearing of wash water where it must be used over and over, and in the prevention of certain surface-tension effects.

Third, the application of centrifugal force to increase artificially the relative difference of density between minerals usually classed together.

As to dry concentration of ore some facts have now been more clearly established than ever. First, dust cannot be concentrated and must be removed. Second, sizing must be very much closer than for wet concentration, which brings up the screening problem. Third, the active body of air must be divided up into small sections, since it is not practically possible to handle ores in large masses continuously, as for example on the Hartz jig. Finally, the dry mill has a labor problem of its own, since the ordinary millman does not understand clearly the underlying phenomena.

Mr. Swart says that the best and most successful attempt at dry concentration yet brought to his attention is the work done by Messrs. Sutton, Steele & Steele, of Dallas, Texas. "If dry concentration—or more accurately, pneumatic concentration—can succeed, it would seem to be along the lines of their dry concentrating table. There are no new principles involved—simply a skilful and intelligent mechanical application of old ones, of which the limits have long been known. Much the same thing might be said of the original Wildley table, yet its combination of old principles was novel and simple, and its

¹See the descriptive article on another page of this issue.

use has revolutionized the methods of ore dressing in many districts. A successful dry process, including necessarily the preliminary preparation of the ore with the concentration devices proper, would undoubtedly work a similar revolution."

The difficulties met with in pneumatic concentration also exist in magnetic and electrostatic processes, although not to the same degree. The dust problem is always serious, yet, due to the fact that most of the successful work in this direction is done on a concentrate or middlings product from preliminary wet concentration, most of the dust having been eliminated as slime, these processes have been able to more than hold their own. Their chief field seems to be in the separation of minerals whose closeness of density does not allow of a separation being made wet or dry through difference of specific gravity.

Magnetic separation is confined for all practical purposes to mixtures containing iron in some form. It has been developed along two lines; first, the use of low-power magnets on ores having a highly permeable iron product for removal; and second, the use of an intense or concentrated magnetic field on materials which are of low permeability. With the exception of magnetite, nearly all ores to be treated by the low-power machines must be roasted. Most of such commercial work now being done is in the removal of pyrite or marcasite from zinc blende.

A comparatively large tonnage of ore is being daily produced by this method, which is commercially and metallurgically successful, and undoubtedly one of the most reliable. It has the advantages that little skilled labor is required, the roast is ordinarily not expensive nor difficult, and the separation can be made as coarse as the crystallization will allow. The machines have large capacity and are simple. The zinc product is high grade and clean, if the preliminary work be well done.

The disadvantages are the large losses in roasting and in tailings, running as high as 35 per cent of the zinc contents in some Wisconsin mills, but as low as 15 per cent in some Colorado practice on finer material. In addition to these must be considered the loss of the sulphur value of the pyrite, the damage in some cases from the sulphurous gases, the difficulty in satisfactorily re-roasting a blende once partially roasted, and the fact that much marmatite possesses about the same magnetic permeability as indifferently or partially roasted pyrite, being therefore lifted out and lost with it. Any galena present is also left with the blende.

A very considerable tonnage of Western marmatite ore is being successfully handled without roasting by the Wetherill magnetic separator and others using an intense magnetic field. These machines lift out the marmatite by reason of the combined iron, leaving the pyrite and galena behind. The avoiding of the roast, and the elimination of the galena from the blende, give this method a most decided advantage over roasting, but like most other processes it is limited in its scope to suitable ores, and there are many ores which it will not handle at all, or only if used in combination with some other process.

This is partly due to the fact that pyrrhotite and sometimes pyrite after heating (which is necessary for drying) possess a magnetic permeability overlapping that of the accompanying blende, and hence are lifted off with it, contaminating it. There is also the consideration that marmatite is variable in composition, the percentage of combined iron running from 3 per cent to 30 per cent. Any "rosin blende" or marmatite low in iron fails to respond to the magnets and is therefore left behind to contaminate the pyrite and galena.

Magnetic separators, particularly those of the belt type (which are in most common use), are further troubled with entanglement of the particles to a greater or less degree. The vibration of the machine, together with the movement of the belt, tends to sort or size the particles, the fines working down through the coarse and lying next to the belt surface so that they are hindered in rising again through the coarser particles

to the magnets. This difficulty increases as the capacity of the machine is raised.

However, the difficulties are not greater than in other branches of ore dressing; they are only different in kind.

Mr. Swart then passed over to a discussion of electrostatic separation and its difficulties.

"The electric charge is like water or air under pressure; leaks are fatal to efficiency." It has been determined that the chief source of static leakage is not through the air or gaseous medium in which the generating plates revolve, but over the supporting, insulating and generating surfaces, due to dirt, chemical films or condensation of moisture. The two former can be guarded against by furnishing the machine with a copious supply of fresh air from which dust and dirt have been filtered, and chemical action reduced by this same rapid change of air. Condensation is prevented by the simple expedient of heating this air supply, the raising of its temperature only a few degrees being sufficient. This remedy is simple and effective and under such conditions a good static machine has been run thirty days without cleaning. The efficiency gradually drops, however, and toward the end of the campaign the electrical output is comparatively small. This varying charge necessitates corresponding adjustments on the separators.

Some fairly satisfactory results have been obtained by running the static machines under a pressure of several atmospheres, but the mechanical troubles offset any gain in efficiency.

"But the goal has been not an improved static machine, but the utilization of the dynamic current, and I am pleased to be able to state that this has been accomplished in Boston by a company of clever and intelligent workers along this line of electric separation. The apparatus consists essentially of a generator, transformer, rectifier, interrupter and condensers—all well understood and thoroughly tried pieces of apparatus. It seems beyond question that this method has already superseded the static machine with a corresponding certainty of results and accuracy of regulation."

Mr. Swart finally takes up "a series of methods of comparatively recent use, but of most intense interest. These are the flotation processes, the oil processes and the surface-tension process. I group them together because I have some reason to believe from results obtained by careful experimenting, and by comparison with the results of others, that the fundamental principles underlying these processes are electrical and identical. I mean that in all probability the law underlying the attachment of a gas bubble, or a film of oil, or a film of air, to a particle of zinc blende in any one of these processes is the same, and has to do with a property or group of properties pertaining to the blende and the medium, varying perhaps in degree, but ultimately the same."

In working out the details of these several processes, the finest sort of practical work has been done. The knowledge gained of the selective action of various oil and grease mixtures, of the use of acids, of the use of varying pressures—running from a high vacuum to several atmospheres—of the effect of temperature, time and of the amount and character of agitation, has added enormously and directly to their commercial value.

"It seems practically a certainty that the flotation processes will eventually be made perfectly selective, separating one sulphide from another as well as sulphides from quartz or other gangue materials, through the use of proper solutions, regulated as to density and temperature, and with regard to the time of treatment and other variable factors. Just what can be done by artificial means toward varying the surface tension of water so that selective action may be obtained in what is known as the surface-tension process, remains to be seen."

Mr. Swart concludes by emphatically urging the necessity for accurate knowledge of theory. We are collecting much data, but not systematically. Most of our work is done in the dark. We are hampered by purely commercial considerations.

"We ought also to begin to take home to ourselves, as definitely bearing on our metallurgical work, the recent researches

and discoveries as to the ultimate constitution of matter—the intra-atomic theory. I feel sure the way to success lies there.”

* * * * *

Some notes on the use of various recent concentration methods for winning zinc concentrates from Broken Hill tailings are given by C. GOEPNER in *Metallurgie* of February 22. In the half year ending May 31, 1907, the Broken Hill Proprietary Co., Ltd., treated 116,240 tons tailings by the Delprat flotation process and produced 25,353 tons of zinc concentrates. The proportion of zinc was 41.81 per cent and increased up to about 43 per cent during the last weeks of that period. It is believed that this improvement was due to the use of deeper pans for separating the concentrates from the sand. It has been found that in order to be successful the material to be treated by the Delprat process must be sufficiently comminuted and for this reason a plant for regrinding the coarser tailings has been installed.

It is said that in the treatment of rich tailings the Delprat process has so far given good financial results. If the output is not of decisive importance, much may be accomplished with it, but it is not an ideal process, and it is possible that it may have to be replaced by other processes in future.

The report of the Zinc Corporation, Ltd., is less favorable. This company had intended to use the Potter flotation process. After preliminary tests made by A. L. Queneau from July to October, 1906, it was decided to introduce the Potter process on a large scale, to be followed by magnetic concentration, in order to enrich the zinc concentrates and obtain a lead concentrate as by-product. The process was used on a large scale from the end of January to the middle of March, 1907. Three thousand one hundred and eighty-three tons crude tailings were treated and there were obtained 49.3 tons of zinc concentrates with a content of 40.1 per cent zinc, 9.21 per cent lead and 9.78 ounces silver per ton; besides this 32.39 tons lead concentrates containing 49.9 per cent lead and 21.4 ounces silver per ton.

The efficiency of zinc recovery from the tailings was 46.28 per cent. But while it had been expected that 500 tons of tailings could be treated per day it was possible to treat only 150 tons. The value of the concentrates was \$2.07 per ton of tailings. If the magnetic concentration had accomplished what had been expected this value could have been increased to \$3.04, but the magnetic concentration plant was not yet ready and could not be used. But it had become evident that on account of very low output and high cost the Potter flotation process was commercially impossible.

Under the management of Huntley an experimental plant was then erected using the Cattermole process, which employs acids and oil. After favorable results had been obtained in the laboratory, the process was carried out in one apparatus on a larger scale. Three thousand, nine hundred and seventy tons of crude tailings were treated and 1091 tons of concentrates were obtained, containing 44.9 per cent zinc, 9.6 per cent lead and 10.1 ounces of silver per ton. Seventy-three per cent of the zinc contents was recovered. The value of the concentrates per ton of tailings treated was \$4.50.

While it was found that the process was satisfactory with respect to output and concentrates, provided the operation was carried out carefully, this was not thought to be sufficient. In order to reduce the cost to a minimum, it was necessary to push the output to the utmost, and in this respect difficulties were encountered. It was then decided not to use the Cattermole process on a large scale, but to introduce the Elmore process instead. It is said that the two processes are identical in many respects and only in the last step of the mechanical separation of the concentrates there are real differences between the two processes. But the Elmore process is said not to need such comminution of the particles and to operate at ordinary temperature, nor does it require skilled labor, while very reliable men are required for operating the Cattermole process.

Together with the Elmore people the Zinc Corporation in-

stalled first an apparatus treating 30 tons of concentrates per day. Rich tailings from Block 10 mine were treated and 89 per cent of the zinc were extracted. Three further experiments with tailings from the British mine gave 83 to 89 per cent extraction and concentrates of 44 to 45 per cent zinc. These results are better than had been expected. The intention is to install first 16 Elmore apparatus and if the results are good to double the installation.

* * * * *

In this connection it will be interesting to give a brief sketch of the Elmore oil process on the basis of some recent publications (B. HAYWOOD in *Western Chemist and Metallurgist*, March; C. GOEPNER in *Metallurgie*, Jan. 8 and 22; R. LINDE in *Metallurgie*, Feb. 8).

Like the processes of Potter and Delprat,² the Elmore process is a flotation process. But while the processes of Potter and Delprat are acid processes, Elmore uses oil to float the metallic particles. It is, however, not the oil alone, which on account of its low specific gravity raises the metallic particles. This became clearly evident from two observations made at an early date.

The first is that the specific gravity of the oil itself is not of such decisive importance as might be thought. The second is that in practice it was found that the oil was able to float two or three times the weight of metal particles which it could theoretically float if the whole phenomenon was due to the low specific gravity of the oil.

It was recognized that the process was not a simple oil flotation process, but that the flotation was due to both oil and gas bubbles. The oil has an "affinity for the sulphide mineral in the presence of water." An oil film forms on the surface of the particle and around this a bubble of gas forms on account of "the affinity of the gas for the oil in the presence of water." Mr. Haywood offers this suggestive comparison with a balloon: The sulphide particles correspond to the basket of the balloon, the gas bubble corresponds to the gas bag and the oil film to the string which connects the basket with the gas bag.

It appears, therefore, that in the Elmore process we have really a combination of oil and gas flotation and the recognition of this fact led necessarily to some important improvements in the process; namely, the use of acid with oil and the employment of a vacuum, as will be described later on.

We will first sketch briefly the old Elmore process, the arrangement of the apparatus being shown in Fig. 1, where 1 is the mixer, 2 is the separator for separating the gangue and water from the metal and oil, and 3 is the centrifugal machine for separating the metal particles from the oil.

The mixture of pulp and water flows through 5 into the mixer 1, while the oil is introduced through 4. The inner surface of the mixer is provided with a helix so that the pulp, water and oil mixture is conveyed from one end of the mixer to the other. At the same time agitation is accomplished by means of wooden beaters 7.

The ore-water-oil mixture flows into the separator 2. The gangue and water settle at the bottom, while the metal particles are floated by the oil to the top and flow over into 18. The gangue and water mixture is siphoned off through 9 into a second mixer, etc.

The metal particles with the oil flow from 18 through the pipe 8 into the centrifugal machine 3. The construction of the latter is as follows: 14 is a non-perforated drum with a round hole 13 at the top and a round hole 15 at the bottom, the latter being closed by the inverted funnel 16. This centrifugal machine, which revolves at a speed of 800 to 1,000 revolutions per minute, is enclosed within the stationary drum 3. 14 is filled with hot water, which assumes the form indicated in the illustration when the drum is revolved. When now the oil and metal are introduced through 8 the oil forms a thin film over the whole inner surface of the water column and creeps up-

² Concerning details, see our Vol. IV, page 49.

wards and over the rim of 14. It then flows down and collects in 17 and is drawn off through 10.

The centrifugal force acts strongly on the metallic particles suspended in the oil film and forces them out of the oil film into the water column against the drum walls. When sufficient metal particles have thus accumulated on the wall, the centrifugal machine is stopped, the funnel 16 is raised and the drum is emptied. The separation is rendered somewhat more easy by preheating the oil.

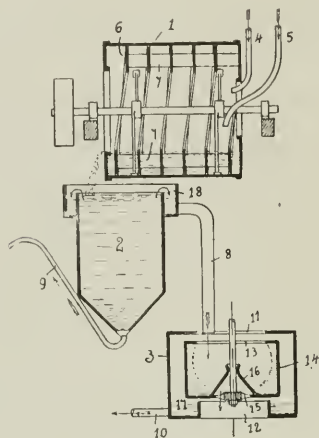


FIG. 1.—OLD ELMORE OIL FLOTATION PROCESS.

This process has been used at various plants, but was not a commercial success. The reason appears to have been that the cost was somewhat too high when the process was applied to crude ore instead of a previously half-concentrated product, and the mines where the process was installed failed to produce suitable ore or tailings for which the method could be used economically.

The process has now undergone in recent years various modifications. Not only has it been rendered continuous so as to reduce the cost of attendance to a minimum, but a considerable saving of oil has also been effected.

Since the floating effect is due not simply to the oil, but to the combined action of oil and gas bubbles, it was found advisable to produce gas bubbles artificially. By mechanically introducing small jets of air, bubbles of too large a size are produced to be efficacious. It was, therefore, found necessary to generate the gas bubbles in the pulp itself. This may be done either electrolytically or by adding sulphuric acid, generating CO_2 and H_2S gas from the carbonates and decomposed sulphides of the ore (as in the ordinary flotation processes). The latter method has been found most convenient and inexpensive.

The sulphuric acid added serves two purposes. First, it has a cleansing effect on the sulphides, making them more amenable to the action of the oil; and second, it exerts a lifting effect. An attraction is caused between the mineral particles themselves, the sulphides forming spongy masses or flocks united by gas bubbles which rise and separate from the gangue, rather than in individual particles.

The lifting power of the gas bubbles is greatly enhanced by producing a vacuum in the separator. This is the second important improvement of the Elmore process and it has been carried into effect in an ingenious way so as to reduce the power cost to a minimum. The principle is diagrammatically shown in Fig. 2.

The ore is first crushed, the size of the crush being governed

entirely by what is required to free the sulphides from the gangue matter. The size is generally from 20 to 40 mesh, although in some cases as high as 150 mesh is necessary. While any method of crushing will answer, rolls are preferred. After wet crushing to the desired size the pulp is passed through a conical tank with rim launder and all unnecessary water is eliminated.

The thickened pulp is then fed by a mechanical valve feeder B (Fig. 2) into the mixer A with a suitable sized stream of 10 per cent acid and crude petroleum. Within A the mass is rapidly and thoroughly mixed by paddles revolving at 30 to 40 revolutions per minute, and escapes into the short arm C of the U copper pipe D by which it is forced by the atmospheric pressure into the inverted cone-shape dome G of the separator, which is kept under a vacuum, through pipe V connected to a vacuum pump.

The upper end of the feed-pipe D enters the center of the separator G. Within the separator the metallic particles float to the top and are carried off through the pipe N into the tank P, while L is the tailings discharge pipe leading to the tank R. The tanks P and R form water seals for the two discharge pipes N and L respectively.

It will thus be seen that the whole arrangement is that of a siphon, so that very little power is required for operating it. The discharge of the tailings pipe L is controlled by a mechanically-operated valve and the rate of flow of the pulp down the pipe L is made slightly less than the inflow through the feed-

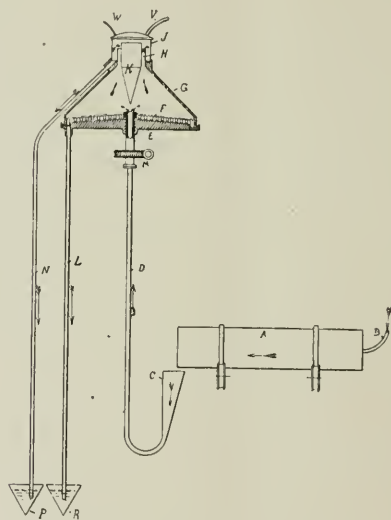


FIG. 2.—NEW ELMORE VACUUM OIL FLOTATION PROCESS.

pipe D. The result is that a small amount of the liquid overflows the lip of the annular space K, this quantity of liquid being sufficient to carry the concentrates which float on the surface down the pipe N into the tank P. The rakes F are caused to revolve by means of the worm and wheel M at a speed of 1 to 2 revolutions per minute and the angle of the rake plates is such as to cause the solid matter in the pulp to travel from the center to the periphery of the conical chamber whence the tailings continually discharge down the pipe L.

The pipe D is 25 to 30 feet long in practice, while L and N are a few feet longer. The conical separating chamber is generally 5 feet in diameter and this size treats from 35 to 45 tons crude ore in 24 hours.

It is stated that in general the operating cost on ores well

sued to the Elmore vacuum process is about the same as the cost of a modern water concentrating plant. The total cost is the sum of the following items: Crushing, crude oil, acid, labor, power, wear and tear.

The amount of crude oil required per ton of ore is 3 to 10 lb. The amount of sulphuric acid per ton of ore 1 to 20 lb. Since the operation is continuous little labor is required (according to Mr. Haywood 2 men for every 4 units of the 40-ton size mentioned above). Aside from the vacuum pump, mixer, revolving rabble and two valves, there are no moving parts, so that the item of wear and tear is almost negligible. As to the power required, this is stated to be about 0.05 hp per ton of plant capacity, hence, say, 10 horse-power for a 200-ton plant. According to Mr. B. Haywood the chief applications of the process are as follows:

While the process is primarily intended for the separation of sulphides from their gangue matter, it is sometimes possible to make very accurate separations between the sulphides themselves.

This is markedly the case with zinc blende and iron pyrites or galena and iron or copper sulphides.

The greatest efficacy of the process is naturally on those ores having heavy gangue matter, such as baryta, some hornblendes, siderite, rhodochrosite, garnet, etc., concentration of which is impossible by gravity. Its use, however, is not by any means confined to this comparatively small class of ores, since the general very high percentage of recovery frequently much more than compensates for the slight increase of cost over ordinary gravity work.

Various forms of sulphides that are difficult or impossible to concentrate with water, such as gray copper, chalcopryrite, steel galena or any galena in hard quartz, where it necessarily slimes badly, the oily minerals—such as molybdenite or graphite—are apt to do exceptionally well by the vacuum process.

Protection of Iron and Steel Surfaces by Means of Zinc.

Mr. SHERARD COWPER-COLES, the distinguished British electrochemist and metallurgist, has recently given an interesting and able résumé of the methods of protecting iron and steel surfaces by means of zinc before the Glasgow Technical College Scientific Society.

Zinc is considered to be the most suitable metal for protecting iron and steel from corrosion, because zinc is electropositive to iron and in the presence of moisture forms a galvanic couple, the zinc dissolving and the iron remaining free from oxidation. Since, however, small pieces of soot or carbon which may settle on a zinc surface will form a galvanic couple in contact with moisture and sulphurous acid (which is present in the atmosphere of all large towns), the zinc is rapidly penetrated in the neighborhood of the carbon so that it is always advisable wherever possible to cover the zinc with a coating of paint.

In all processes of galvanizing it becomes necessary to remove the scale and oxide from the iron surface. The preparation of the surface for "sherardizing" and "cowperizing," however, does not require so much care as in the case of hot galvanizing and electrogalvanizing.

Usually iron and steel to be galvanized are pickled and afterwards washed. However, Mr. Cowper-Coles thinks that the operation of washing is often not carried out carefully enough and that "is one of the reasons why galvanized sheets and wire now put on the market are not so durable as the galvanized iron produced some twenty-five years ago. Another reason is that too much zinc is squeezed or wiped off."

There are now four commercial processes for applying zinc

to iron and steel. First, hot or molten galvanizing; second, electro or cold galvanizing; third, sherardizing or dry galvanizing; fourth, cowperizing or vapor galvanizing.

Hot Galvanizing.—The hot or molten process was intro-

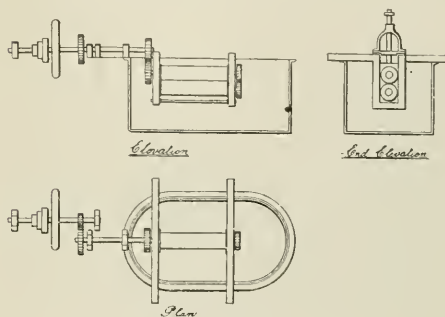


FIG. 1.—HOT GALVANIZING BATH, WITH ROLLS.

duced as early as 1846. It consists in immersing the article, after removal of all scale, oxide and grease, into a bath of molten zinc. The temperature of the zinc varies from the melting point of zinc to 800° F., according to the thinness of the coating required and the nature of the work under treatment. The higher the temperature, the thinner the coating; but the saving is not as great as might be expected, since the

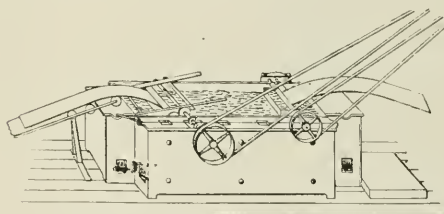


FIG. 2.—HEATHFIELD SHEET GALVANIZING MACHINE.

higher the temperature, the more zinc combines with the iron in the bath or the article, to form a zinc-iron alloy which has to be removed from the bath from time to time. The temperature of the bath is generally, therefore, kept as low as possible, and the excess of zinc is removed by shaking the articles or, if of suitable section, passing them between rollers on a bed of sand resting on the top of the molten zinc.

A typical form of rollers employed in galvanizing pots for ensuring a more even coating of zinc is shown in Fig. 1, the



FIG. 3.—CONTINUOUS PLANT FOR GALVANIZING SHEETS.

sheets being fed into the rollers by hand at the rate of about 1 ft. per second.

Messrs. Heathfield's galvanizing machine is shown in Fig. 2. Muriate of ammonia is placed in one end of the machine through which the plates enter, and sand at the other end through which the plates leave. Such a machine will turn out 12 tons or more of galvanized sheets, 14 to 30 gauge, in 10½ hours.

The galvanizing pots are made of wrought iron or steel with riveted or welded joints, and usually contain about 25 tons of molten zinc for sheet galvanizing, although they are often made large enough to contain 200 tons or more of metal when large plates or tanks have to be dealt with.

The bottom of the galvanizing pot is generally arranged on

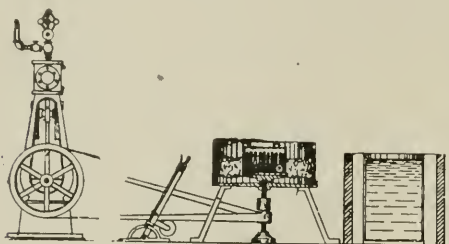


FIG. 4.—WIRE COIL GALVANIZING MACHINE.

solid masonry, the brickwork being built up around the pot so as to provide a fire space between the brickwork and the iron pot. A number of draft holes are left in the brickwork, which are used for regulating the draft by removing or replacing bricks.

Fig. 3 shows the general arrangement of a plant for galvanizing sheets continuously.

Wire is coated with zinc by passing a number of wires, arranged parallel to one another, through the bath. As the

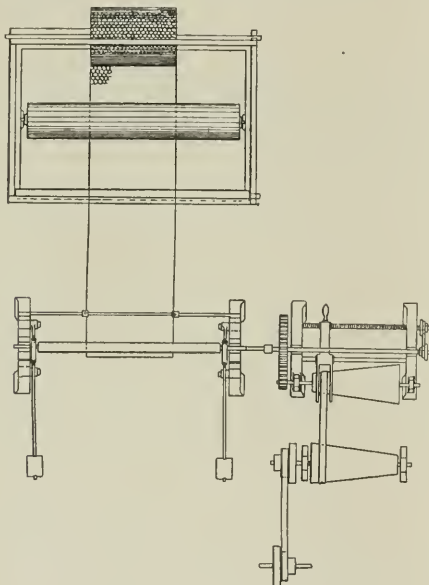


FIG. 5.—MACHINE FOR GALVANIZING WIRE NETTING.

wires leave the molten zinc they are drawn through sand or wiped with asbestos to remove some of the zinc.

Another process consists in placing the entire coil in the molten zinc and then removing some of the zinc by centrifugal force in an apparatus, as shown in Fig. 4.

Wire netting is covered with zinc by a machine such as is shown in Fig. 5, arrangements being made to vary the speed of the winding roller as the size of the roll of wire netting in-

creases. The amount of zinc required for galvanizing wire netting is considerable, due to the filling up of the interstices in the twisted wire. This difficulty has been surmounted by making wire netting with the mesh welded together by means of small electric welding machines.

One of the chief advantages of hot galvanizing, as compared with other processes, is the rapidity with which the work can be done. The soldering action due to hot galvanizing is found to be a considerable advantage when galvanizing thin tanks and such like articles, which are not caulked to make them water-tight, but, on the other hand, it is responsible for a good deal of bad work which otherwise would not be passed. The process of hot galvanizing is an expensive one, due to the necessity of keeping the zinc molten continuously; the zinc, especially when overheated, rapidly dissolves the iron bath; it also dissolves off some of the iron of the articles immersed in the

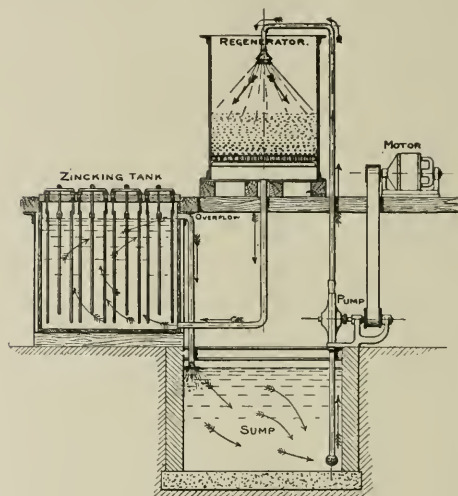


FIG. 6.—ELECTROGALVANIZING WITH REGENERATION OF ELECTROLYTE.

molten zinc, with the result that a large quantity of iron-zinc alloy is formed in the bath of molten zinc which has to be removed at short intervals.

Electrogalvanizing.—The electrolytic process of coating iron and steel surfaces with zinc has been brought in recent years to such perfection that it can be worked by any intelligent workman. The British Admiralty use the process extensively for detecting flaws in tubes, forgings, etc., before they are put into actual use. (The flaws are shown up owing to their not taking on the galvanizing.)

While in this country mostly soluble zinc anodes are used to keep up the correct amount of zinc in the bath, Mr. Cowper-Coles remarks that this is not necessary, since the electrolyte may be easily regenerated and brought up to the correct amount of zinc by passing it through a filter bed containing zinc dust and carbon. The automatic cycle of operation of electroplating, running off the electrolyte, regenerating it and returning it to the electrolytic vat, is illustrated in Fig. 6.

Lead anodes may, therefore, be used and they have the advantage that they do not need to be removed. When zinc anodes are used about 50 per cent only goes into solution and a large proportion crumbles away into the electrolyte. In this case if regeneration of the electrolyte is employed, the zinc which crumbles away from the anode is caught by the filter bed and is gradually dissolved. According to Mr. Sherard Cowper-Coles the regeneration of the electrolyte (whether zinc anodes

or lead anodes are employed) offers quite a considerable saving.

Electrogalvanizing has been very extensively applied to boiler and economizer tubes for battleships and destroyers. The tubes

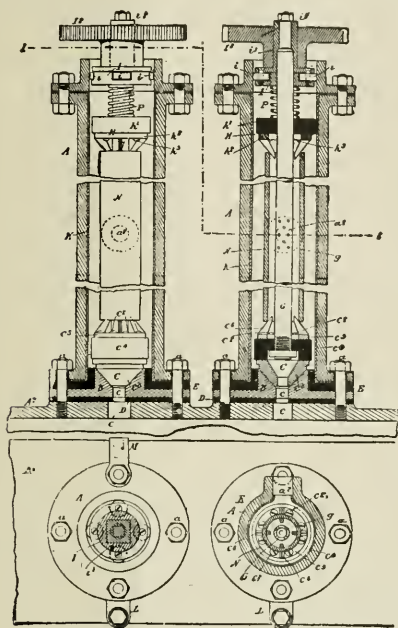


FIG. 7.—COATING TUBES INSIDE AND OUT.

are usually suspended vertically and so arranged that they can be rotated by hand.

Fig. 7 shows an arrangement for coating tubes inside and out. Small articles, such as bolts and nuts, are zincd in revolving barrels, or in such an apparatus as shown in Fig. 8.* By the addition of various organic substances zinc can now be deposited in a bright form.

(Sherardizing.)—The process of sherardizing or dry galvanizing has already been described in detail in an able and interesting article of Mr. Alfred Sang in our Vol. V, p. 187.

The iron articles to be rendered non-corrosive, after having

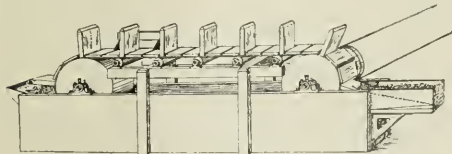


FIG. 8.—APPARATUS FOR PLATING SMALL ARTICLES.

the black scale removed, are placed in a closed iron receptacle charged with zinc dust, which can be kept stationary or rotated. The contents of the drum are heated to a temperature of 500° to 600° F. for a time varying from 30 minutes to several hours according to the nature and section of the iron to be coated. After withdrawing the drum from the heating oven or furnace, it is preferably allowed to cool, and it is then opened and the iron articles removed, when they are found to be coated with a fine homogeneous covering of zinc, the thickness of the zinc depending on the time and temperature.

The process is a very economical one, as the temperature is low and great economy is effected in the amount of zinc consumed, due to the fact that less zinc is required to give the same protective coating than would be necessary in the case of the hot or electrogalvanizing processes, and as all the zinc is

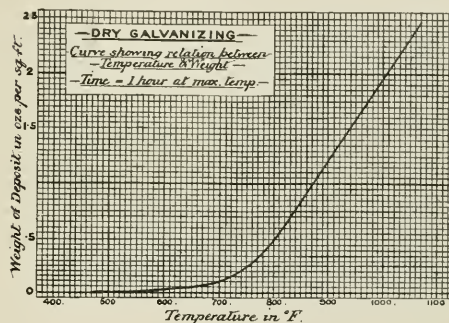


FIG. 9.—INFLUENCE OF TEMPERATURE ON THICKNESS OF ZINC DEPOSIT IN SHERARDIZING.

consumed, there are no skimmings or dross formed as in the hot process. The zinc powder used in the process is the zinc dust of commerce and must not be confused with zinc oxide.

The receptacle in which the zinc dust is placed and heated is preferably air tight, and the air is exhausted so as to prevent the formation of too much oxide. If this is not feasible, it is found advisable to add about 3 per cent by bulk of carbon in a very fine state of division. If the percentage of oxide is allowed to increase beyond certain limits, it is found that the deposits become dull in appearance, instead of having a bright, metallic lustre, although good deposits of zinc can be obtained from zinc dust containing only 35 per cent of metallic zinc. Articles

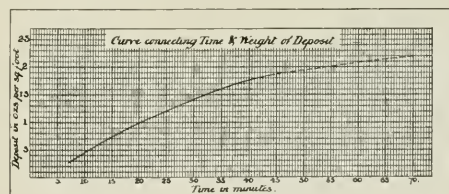


FIG. 10.—INFLUENCE OF TIME ON THICKNESS OF DEPOSIT IN SHERARDIZING.

coated with grease receive as good, if not better, coatings of zinc than those which are free from grease. This fact is of considerable importance, as it enables machined work, such as bolts, nuts, screws, etc., to be placed direct after machining into the dry galvanizing drum without any preparation or cleaning.

Temperature and time are the two factors which regulate the thickness of the zinc deposit, as shown by the two diagrams, Figs. 9 and 10. While it is always recommended that zinc surfaces exposed to the weather should be painted, sherardized surfaces admirably resist atmospheric influences without further protection.

In practice dry galvanized iron and steel are found to withstand the ordinary corrosive agents to which galvanized iron is exposed to a remarkable degree. Even after the apparent removal of all the zinc by filing or abrasion, the iron is still non-corrosive. This valuable property is doubtless due to the protective action of the zinc-iron alloy which forms on the boun-

*See also description of the apparatus of the U. S. Electro Galvanizing Co. on page 332 of our Vol. V.

dary line between the iron and zinc, as has been proved by micro-photographs. As dry galvanizing is effected at a very much lower temperature than hot galvanizing, the temper of steel wire is not reduced as it is in the latter process. A number of steel and iron bolts galvanized at varying temperatures, when tested for tensile strength, were found to be equal in strength to bolts which had not been dry galvanized.

The following table gives the results of tests for tensile strength upon four untreated and four sherardized specimens of steel rods:

DIMENSIONS.		AREA.	EXTENSION.			ON ORIGINAL AREA.				REMARKS.	
			Reduction of Area at Frac- ture. Per Cent.	On Two Inches. Per Cent.	Insat Two Frac- ture. Per Cent.	Elastic Limit		Maximum Stress.			
						(Yield Point). Lbs. Per Sq. Inch.	Tons Per Sq. Inch.	Lbs. Per Sq. Inch.	Tons Per Sq. Inch.		
Untreated	Steel Rod.....	0.276 by 0.277	0.0774	—	1.0	—	70,358	31.41	121,676	54.32	Irregular fracture. Broke outside datum points, in jaws. Broke outside datum points, in jaws. Irregular fracture. Broke outside datum points, in jaws. Broke outside datum points, in jaws.
"	"	"0.274 by 0.274	0.0750	6.6	3.0	—	49,280	22.0	150,796	67.32	
"	"	"0.278 by 0.278	0.0772	—	3.5	—	73,987	33.03	149,408	66.70	
"	"	"0.283 by 0.268	0.0758	3.7	3.0	—	69,440	31.00	153,932	68.72	
Sherardized	Steel Rod....	0.279 by 0.285	0.0795	10.9	7.0	—	113,545	50.69	156,598	69.91	Steel Rods treated.
"	"	"0.274 by 0.279	0.0764	6.7	4.0	—	102,032	45.55	148,064	66.10	
"	"	"0.274 by 0.283	0.0775	15.9	6.0	—	Not Observable.		154,918	69.16	
"	"	"0.276 by 0.281	0.0783	4.8	3.5	—	108,147	48.28	149,632	66.80	

The process of sherardizing has recently been turned to account for the inlaying and ornamenting of metallic surfaces, enabling results to be obtained similar to inlaying, but with the additional advantage that there is no risk of the metals finally separating.

The new process also enables a variety of effects to be obtained and a number of metals to be blended together which has hitherto been impossible, and alloys of many colors and tints to be obtained in the one operation of baking. The thickness and depth to which the metals are to be inlaid can be controlled at the will of the operator.

The *modus operandi* of the process consists in coating the article with a stopping-off composition, those portions which are to be inlaid being left exposed. The composition is about the consistency of cheese, so that it can be readily cut with a knife, the design is traced with a sharp-edge tool, and those portions to be removed are lifted and cleared away. The object thus prepared is placed in an iron box containing the metal which is to be inlaid in a powdered form.

If zinc is the metal to be inlaid, zinc dust is the powder employed. The iron box holding the powdered metal and the objects to be ornamented is then placed in a suitable baking oven and heated to a temperature many degrees below the melting point of solid zinc, which is 686° F., so that the temperature to which the zinc dust is heated is about 500° F. The time and temperature are regulated according to the thickness and depth of the inlaying which is required to be obtained and varies from a few minutes to several hours.

A useful type of furnace or baking oven for general work, such as panels, trays, etc., is shown in Fig. 11 and consists of a wrought-iron box, 8 ft. long, 4 ft. broad and 1 ft. deep. The box is half filled with zinc dust and the articles to be baked are placed in the zinc dust and well covered with it. A lid is placed on the top of the box, and over this an iron frame, balanced with counter weights, lined with fire bricks and fitted with a small central flue, which draws the heat from the burners up to the sides of the box and over the top, thus ensuring even heating of the contents of the box.

It is found that the inlaying metal, in the case of zinc, is very much harder than the brass or copper into which it is inlaid. A feature of considerable importance is that a variety of color and alloys can be obtained in the one operation of baking. Take, for example, a copper tray, which it is desired to inlay with zinc and at the same time to convert certain portions of the copper into brass. This can be done by varying the thick-

ness of the stopping-off composition, and by baking at a somewhat higher temperature than would otherwise be employed. The result is that certain portions can be converted into golden-colored brass, the other portions remaining unalloyed copper.

Copper and zinc give very marked contrasts in color. Softer contrasts can be obtained between zinc, aluminium, tin, nickel and cobalt and similar colored metals. The new process is not confined to flat surfaces, but can readily be applied to raised surfaces.

This new process of burning in and blending metals enables

a very beautiful effect to be obtained with great subtlety of color, the tones ranging from silver white zinc to yellow brass and bronzes of various shades, graduating to red copper and autumnal shades of yellows and golden browns.

A great charm about this new process of inlaying metals, and one that is unique, is that the inlay has not the sharp line of demarcation, as is essential to damascening, but a soft transition from the inlaid metal to the surrounding metal. For instance, in the case of inlaying zinc into copper it will be observed that the zinc is surrounded by a band or halo of a golden-colored alloy.

Cowperizing.—The process of cowperizing or vapor galvanizing is distinctive from all other processes inasmuch as the

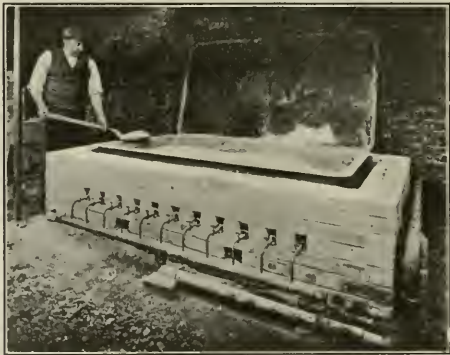


FIG. 11.—FURNACE FOR INLAYING.

articles coated with zinc are not brought into contact with molten zinc or any of its compounds, but placed in a separate chamber into which zinc vapor is passed.

A convenient form of apparatus is shown in Fig. 12. It consists of an inner drum C, composed of wire netting or gauze, in which the articles to be cowperized are placed. This cage or hollow drum is slowly rotated inside an outer cylinder B composed of wrought iron, in which the metallic zinc is heated by means of gas or an electric furnace, or any other suitable means, to a temperature sufficiently high to volatilize the zinc.

Hydrogen gas is forced into the apparatus through the tube marked A and a pilot light of hydrogen is kept burning through a small hole in the door marked D, which makes a gas-tight joint when closed. The beneficial effect of the hydrogen on the color and adhesion of the deposit is probably due to its reducing action. The apparatus for cowperizing has to be modified to suit various requirements, but in almost all cases it is necessary to move the objects to ensure their being evenly coated with zinc.

The process has also been successful when applied to decorating porcelain and metallic surfaces with a brilliant coating of metallic zinc.

The author finally sums up the comparative advantages of the different processes. He also gives tables of their cost of operation, but since these contain cost of labor and incidentals as an important item, and since the figures are based on English conditions, these tables are not reproduced here.

Electrogalvanizing Versus Hot Galvanizing.—Prof. C. F. Burgess¹, of the University of Wisconsin, has contrasted the hot and cold processes as follows: (1) In hot galvanizing the heat required is considerable, as much is lost by radiation and in bringing the articles under treatment to the requisite temperature. (2) The loss of zinc is also very considerable owing to oxidation at the surface of the zinc, and from combination of zinc with the sal-ammoniac, and with the iron of the treated articles, and through corrosion of the iron vessel. These losses amount to about 50 per cent of the zinc. The cold or electro-

is required, no dross or skimmings are formed; there is no danger of explosion, breaking of castings or distortion of thin iron work. Dry galvanized machined work does not require refitting, as the coating is evenly distributed. There is not the same reduction in tensile strength as in the case of hot galvanizing; work can be placed direct in the dry galvanizing drum from the pickling vat without drying; the process can be worked intermittently without waste; iron can be coated with zinc to any desired thickness, and the whole of the zinc is consumed without waste. The depreciation of plant is small compared to hot galvanizing.

Comparison of Hot, Cold, Galvanized and Sherardized Surfaces

—Surfaces obtained by hot and cold galvanizing and sherardizing are different in each case, but they can readily be distinguished by anybody conversant with the three processes. In case of hot galvanizing the surface is spangled, or if not spangled has the appearance of cast metal. In the case of cold galvanizing the surface is free from spangles and has a matted or frosted surface, uniform if the work has been well executed. Sherardizing is again distinctive from the two former processes; the general appearance resembles more that of cold galvanizing than hot galvanizing, but is more lustrous and metallic, and is uniformly distributed over the whole surface, which is not the case with the hot and cold galvanizing processes. The sherardizing process, although similar to cold galvanizing, is also similar to hot galvanizing in other respects, inasmuch as the zinc alloys with the iron and forms a protective zinc-iron alloy intermediate between the zinc coating and the underlying metal.

The copper sulphate test, known as Preece's test, is not applicable as a comparative test of the thickness of zinc applied by the sherardizing or electro-zincing process for the following reasons: On applying Preece's tests to sherardized and hot-galvanized articles coated with an equal thickness of zinc the former requires from three to four times the number of immersions which suffice to remove the zinc from the latter: when hot-galvanized articles are placed in a saturated solution of copper sulphate the copper is precipitated to a loose form, but when sherardized or electro-zincing articles are similarly treated the copper adheres firmly to the zinc and no fresh surface is exposed, apparently due to the deposit of zinc applied by the electro-zincing and sherardizing processes having a fine matted surface.

It would appear from these observations that the apparently great resistance to corrosion of sherardized iron when subject to Preece's test is due to the protection of the zinc by the deposited copper; so experiments were made with a solution of ferric sulphate, which dissolves zinc without forming a precipitate on the zinc coating.

To test this known areas of sherardized and hot-galvanized plate were exposed to the action of ferric-sulphate solution for an equal period and the amount of ferrous salt formed by the reducing action of the zinc determined. The column headed "Weight of Zinc Dissolved" shows the relative corrosion.

Nos.	Sample.	Zinc per sq. ft.	
		grams.	Weight of zinc. Dissolved grams.
1.	Sherardizing	26.908	0.080
2.	Sherardizing	26.908	0.074
3.	Sherardizing	22.93	0.057
4.	Hot-galvanizing	22.12	0.058
5.	Sherardizing	31.116	0.034

Sample No. 2 was moistened with water and allowed to dry; the oxide formed appears to protect the zinc, and this protection is more marked if water is allowed to act for a longer period than was permissible in these experiments. It will be noticed that samples 1 and 2, which had a thicker coating than samples 3 and 4, dissolved to a greater extent than samples 3 and 4, which had practically the same weight of zinc coating, dissolved.

Sample 5 was sherardized copper and, although the zinc coat-

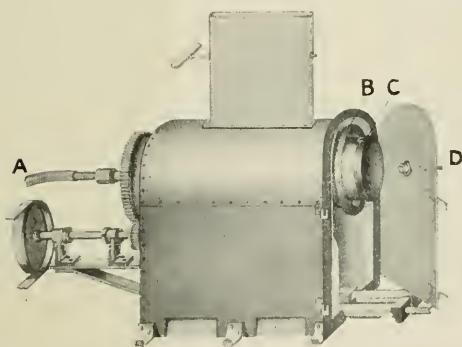


FIG. 12.—COWPERIZING APPARATUS.

lytic process, on the other hand, has the following advantages:

(1) There is no loss of heat. (2) No difficulties are introduced by the high temperature of 770° F. required in the hot process. (3) No skilled workmen are requisite. (4) The loss of zinc is small. (5) For equal quantities of zinc used the electrolytic process gives a better protection. (6) The wear and tear of the plant per year is less than to per cent, whereas in the hot process it is some 50 per cent. (7) Articles of any size can be galvanized. (8) The electrolytic bath is always ready, while the melting of the zinc in the hot process requires time. (9) The thickness of deposit can be easily controlled. (10) Objects of art can be submitted to the cold process without any risk of damage.

Sherardizing Versus Hot Galvanizing.—The process of sherardizing has the following advantages over hot galvanizing, according to Mr. Cowper-Coles: There is no waste of zinc due to the formation of zinc-iron alloys; less zinc is required to give the same protective coating, the zinc being evenly distributed; the temperature required is lower, consequently the amount of fuel consumed is less. The labor is less, as the articles do not require to be cleaned as carefully as in hot galvanizing. No flux

¹See also Prof. Burgess' paper on this subject in our Vol. III, p. 17.

ing was the heaviest, yet the corrosion was in this case the least. On testing this sample with copper sulphate solution, as in the other cases, instead of a brown precipitate of copper, a bright, metallic deposit was obtained, and no further action seemed to occur.

From the result of these experiments and other tests, it may be concluded that sherardizing offers equal and probably greater resistance to ordinary corrosive influences than hot galvanized iron coated with an equal weight of zinc, and the resistance is considerably increased by repeated moistening and drying, so as to form an oxide which renders the surface less soluble.

From experiments made to elucidate the nature of the union between a sherardized coating and the base metal in comparison with the electrogalvanizing method and from microphotographs of the etched joint produced the author concludes that in the case of hot galvanizing and sherardizing there is not merely mechanical adhesion between the coating and the base, but that an alloy of zinc and iron is actually formed at the surface of junction, and this film of alloy is less liable to corrosion than is the iron itself.

Cowperizing Versus Hot Galvanizing.—The cowperizing process is especially suitable for coating articles with threads, or which require to be accurately fitted, as the zinc is evenly distributed. The zinc combines with the surface of the iron, forming a rustless zinc alloy. The articles on removal from the cowperizing drum do not require any cleaning or washing. The process is cheaper than hot galvanizing, as there is less handling and the amount of heat required is small, as only a small quantity of zinc has to be heated.

The process, like sherardizing, is not suitable for coating articles which are dependent on the soldering action of molten zinc to make them watertight, or when the spangled effect obtained by hot galvanizing is an essential condition. The whole of the zinc is consumed; there is no dross or residue formed. The process can be quickly started, as there is no large quantity of metal to get hot.

"Electro zincing, sherardizing and cowperizing all have a large field of application and will greatly increase the amount of iron coated every year with zinc, as each process has its own peculiarities which render it more suitable than any other process for specific purposes, and in many cases enables iron objects to be coated with zinc, which could not be done by the process of hot galvanizing."

Metallurgical Calculations.

By J. W. RICHARDS,

Professor of Metallurgy in Lehigh University.

The Metallurgy of Zinc—II.

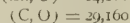
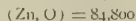
REDUCTION OF ZINC OXIDE.

Since metallic zinc boils under atmospheric pressure at 930° C., and carbon does not begin to reduce zinc oxide until 1033° is reached, the zinc reduced is necessarily obtained in the state of vapor. To make the reaction proceed fast, a temperature of the charge inside the retorts of 1100° to 1300° C. at the end is necessary. A large amount of heat is absorbed in the reaction, which must be supplied as a current or flow of heat through the walls of the retort in order to keep the reaction and reduction going. Since the walls of the retort are fire-clay, averaging 4 centimeters (1.6 inch) thick, there must be a considerable difference of temperature (temperature head) between the inside and outside of the retort in order to keep up the flow of heat inward.

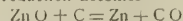
THERMOCHEMICAL CONSIDERATIONS.

The heat of formation of zinc oxide, at ordinary temperatures, is 84,800 Calories for a molecular weight, 81 kilos, of oxide, as determined by thermochemical experiment. This means that cold zinc uniting with cold oxygen, and the hot product cooled down to the same starting temperature, results

in the evolution of heat stated. Cold carbon uniting with cold oxygen to cold carbonous oxide, C O, gives similarly 29,160 Calories per molecular weight, 28 kilograms, of gas formed. These facts are expressed thermochemically as



The equation of reduction becomes



This means that if we start with cold zinc oxide and cold carbon, the heat absorbed is 55,640 Calories ending up with cold products, zinc and CO at ordinary temperatures.

What is actually done in practice, however, is to first heat the Zn O and C to a high temperature, at least to 1033°, and then to supply the heat of the reaction at that temperature, producing zinc vapor and CO gas, both at 1033°. The process of reduction, therefore, resolves itself plainly into two steps: (1) heating the charge up to the reacting temperature, (2) supplying the latent heat of the chemical change at that temperature.

HEATING UP THE CHARGE.

The charge usually contains more carbon than is theoretically necessary for reduction of the zinc oxide, because some is consumed by air in the retort, some in reducing iron oxides, and some is left behind unused; it is cheaper to lose carbon than unreduced zinc oxide. However, making the calculation on the theoretical amount of carbon only (anyone can modify it for any excess of carbon used in any specific case) we need to know the heat necessary to raise these reacting substances to the temperature of reaction.

The heat in 1 kilogram of zinc oxide at various temperatures was determined in the writer's laboratory as 0.12121 + 0.0000315 t². The heat in 1 kilogram of carbon at temperatures above 1000° is represented by 0.51—120. We have the heat necessary to raise our 81 kilograms of Zn O and 12 kilograms of carbon to 1033° as

$$\begin{aligned} \text{Zn O: } 0.1212 (1033) + 0.0000315 (1033)^2 \times 81 \\ = 159 \times 81 = 12,879 \text{ Cal.} \\ \text{C: } [0.5 (1033) - 120] \times 12 = 396 \times 12 = 4,752 \text{ "} \\ \text{Sum} = 17,631 \text{ "} \end{aligned}$$

This quantity represents the heat per 81 of oxide and 12 of carbon, or 93 of charge containing 65 of zinc. Per 100 kilograms of oxide, containing 800 kilos of zinc, it would be

$$\frac{17,631 \times 1000}{81} = 217,670 \text{ Calories.}$$

It should be noted that this quantity is actually proportional to the weight of the charge, ore plus reducing agent, and independent of the amount of zinc in it. A ton of poor ore will practically require as much heat to bring it up to the reaction temperature as a ton of rich ore, so that these costs are proportional to the weight of charge treated and not to the weight of zinc it contains.

If the charge is heated electrically, the amount of electric power needed for heating up can be calculated, assuming an average loss of 10 to 30 per cent. of the total heat by radiation and conduction from the furnace.

Illustration:

A retort contains 300 kilograms of charge mixture and is heated electrically to 1033°, the reaction temperature at an efficiency of 75 per cent., by an electric current of 250 horse-power. How long will the heating-up period last?

Solution:

Heat needed in the charge, $217,670 \times 0.3 = 65,300$ Calories. Heat to be supplied $= 65,300 \div 0.75 = 87,070$ Calories. Power applied supplies $635 \times 250 = 158,750$ Calories per hour. Time required $87,070 \div 158,750 = 0.55$ hour $= 33$ minutes.

If the charge is heated by furnace gases outside the retort we must take into consideration that the fire-clay is a poor conductor, that the rate of transmission of heat through the walls falls off as the charge becomes hot, and that the outside sur-

face of the retort must be kept well above 1033° in order to get the charge to that temperature in a reasonable time. The conductance of fire-clay for high temperature is 0.0031; that is, 0.0031 gram Calories pass through each square centimeter per second, if one centimeter thick, per 1° C. difference of temperature. When the charge is cold, the inner surface of the retort may be reduced in temperature to a low red heat, say, 500° , and towards the end of the heating-up period its temperature becomes at least 1033° , while the outer surface is kept continually at 1200° , let us say, by the furnace gases. During the heating-up period there is a difference of temperature producing heat flow of 700° , for a short time, down to, say, 200° , which we may average up as 300° heat difference. The heat conductivity of the material of the retort and the thickness of its walls have everything to do with the rate at which the heat can get through and the charge be heated up to the reaction temperature.

Problem 130.

An oval zinc retort is 130 centimeters long, 30 centimeters diameter outside, one way, and 15 centimeters the other, and its walls are 3 centimeters thick. It is charged with 30 kilograms of ore and 12 kilograms of reduction material. The temperatures of the charge in the retort and of the gases outside the retort were as follows:

	In Retort Outside Difference		
	0°C.	1067°C.	1067°C.
At starting.			
In 0.5 hour	350	1067	717
" 1.0 "	600	1067	467
" 1.5 hours	781	1067	286
" 2.0 "	814	1100	286
" 2.5 "	869	1100	231
" 3.0 "	924	1110	187
" 3.5 "	957	1155	198
" 4.0 "	935	1166	231
" 4.5 "	935	1138	203
" 5.0 "	946	1144	198
" 5.5 "	946	1155	209
" 6.0 "	979	1166	187
" 6.5 "	1001	1177	176
" 7.0 "	1034	1177	143

Average, 319

Take 159 Calories per kg. as the heat required to bring the ore to 1034° and 396 for the reduction material.

Required:

The average heat conductivity in C. G. S. units of the material of the retorts, in the range given, assuming the inner surface of the retort to be at the same temperature as the charge.

Solution:

Heat passing through the retort walls in 7 hours:

$$159 \times 30 = 4770 \text{ Calories}$$

$$396 \times 12 = 4752 \text{ "}$$

$$\hline 9522 \text{ "}$$

$$\text{Per second} = 0.378 \text{ "}$$

$$= 378 \text{ gram. cal.}$$

Surface of retort:

$$\text{Periphery } \sqrt{30 \times 15} \times 3.14 = 66 \text{ cm.}$$

$$\text{Area of sides, } 66 \times 130 = 8580 \text{ sq. cm.}$$

Heat passing through each square cm. per second

$$378 \div 8580 = 0.044 \text{ Cal.}$$

Heat passing per 1° difference

$$0.044 \div 319 = 0.00014 \text{ Cal.}$$

Since thickness is actually 3 centimeters, conductance in C. G. S. units is:

$$0.00014 \times 3 = 0.00042.$$

Correction:

This coefficient of conductance is far too low. The reason is that the inner temperature, the temperature of the charge, is always lower than the temperature of the inside surface of the retort, and the difference of temperature between the outer and

inner walls of the retort must have been far less than the average, 319° . If we take the coefficient of conductance as determined by experiment for firebrick, viz., 0.0031, then the average difference of temperature between the inner and the outer walls of the retort would be:

$$319 \times \frac{0.00042}{0.0030} = 45^{\circ} \text{ C.}$$

This is more likely than that the conductance of the retort material should be so extraordinarily low. In fact, we are led to the conclusion that the poor heat conductivity of the charge itself is the chief obstacle to its rapid heating, and that pre-heating of the charge would be very advisable if it could be done by some of the waste heat of the gases leaving the furnace.

DISTILLATION OF THE CHARGE.

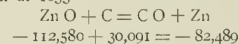
The driving off of the zinc is altogether a different operation from the heating up of the charge to the stated reduction temperature. It is an endothermic chemical operation, comparable to the boiling of water at a constant temperature, the latent heat of the chemical reaction is exactly comparable to the latent heat of vaporization. The temperature must be kept up to the temperature of reduction in order for the reaction to take place at all, and then heat-Calories must be supplied at that temperature to keep the reaction going, and the reduction proceeds *pari passu* with the quantity of heat supplied at that constant temperature. The question now is: what is the latent heat of this reaction at the reaction temperature?

We must for this purpose know the heat of formation of the substances involved, Zn O and CO, at 1033° . The method of calculating these is too long to insert here, but may be learned from the writer's book on Metallurgical Calculations, Part I, p. 51. We have the heats of formation from the elements as they exist at 1033° :

$$(\text{Zn, O})^{1033} = 112,580$$

$$(\text{C, O})^{1033} = 30,091$$

and the reaction at 1033°



This is seen to be nearly 50 per cent. greater than the heat of the reaction calculated to ordinary temperatures, from the ordinary heats of formation as taken from thermochemical tables. The metallurgist should understand this difference, for it is one of the utmost importance in thermochemical calculations, if we want our calculations to represent actual conditions and to check up with practice.

This amount of heat is proportional to the zinc oxide reduced or to the zinc distilled from the charge, but not to the weight of ore charge itself. This requirement will, therefore, be greater, per retort full of material, the richer the charge is in zinc. It is a constant requirement for a given output of zinc, and not per given weight of ore treated.

The heat required for the reduction, therefore, as distinguished from the heating-up period, is

$$\begin{array}{rcl} 82,489 & & \\ \hline & = & 1,018 \text{ Calories per kg. of Zn O reduced} \\ 81 & & \\ 82,489 & & \\ \hline & = & 1,269 \text{ " " " " Zn distilled off} \\ 65 & & \\ \hline & = & 1,269,000 \text{ " " ton " " " } \end{array}$$

Furnishing this reduction heat, at the high temperature required, is the larger part of the heat needed in the whole process. We see that it is some 4.7 times the amount of heat needed to raise the materials to the reduction temperature.

Problem 131.

The retort charge of Problem 130 was kept at the reduction temperature for 14 hours, the temperature outside the retort being gradually raised to 1300° and the average difference in temperature between the gases and the charge being 147° , and

there being distilled from the charge in that time 18 kilograms of zinc.

Required:

The average heat conductance in C. G. S. units of the material of the retort from the above data and assumptions.

Solution:

The heat furnished in the 14 hours was as follows:

$$1,269 \times 18 = 22,842 \text{ Calories.}$$

Heat furnished per hour:

$$22,842 : 14 = 1,632 \quad "$$

Heat furnished per second:

$$= 0.453 \quad "$$

$$= 453 \text{ calories.}$$

Heat passing each sq. c.m. of retort surface per second:

$$453 \div 8,580 = 0.053 \text{ calories.}$$

Per 1 difference:

$$0.053 \div 147 = 0.00036 \quad "$$

Conductance, in C. G. S. units:

$$0.00036 \times 3 = 0.00108$$

Remarks: This conductance calculates out 2.5 times as great as from the data on the heating-up period, the reason of the higher value being that the charge is at nearly uniform temperature during this reduction period, and therefore the difference between the temperature taken in the middle of the charge and the true temperature of the inner walls of the retort is less than before, and the error from this source less. If we make the same assumption as in the correction to the previous problem, i. e., take the conductance of the retort material as 0.0030, the difference in temperature of the outer and inner walls of the retort during this period would calculate out

$$\frac{147 \times 0.00108}{0.0030} = 53^\circ$$

while the center of the charge was then $147 - 53 = 94^\circ$ cooler, on an average, than the inner wall of the retort from which it was deriving its heat.

These figures appear reasonable, and the writer would conclude, from the data so far available, that the conductance 0.003 probably represents a good approximation to the correct value for zinc retort material, but that, in order to use it, we should have more experimental data as to the average difference between the temperature of the inner walls of the retort and the temperature of the charge at various points in the retort.

Problem 132.

A zinc ore containing 50 per cent of zinc is mixed with 40 per cent of its weight of small anthracite coal, and retorted in a Belgian furnace. The recovery of zinc was 82 per cent of the zinc content of the ore. The consumption of anthracite to heat the furnace was 2.25 tons per 10 of ore. The anthracite contained 90 per cent of carbon and 10 per cent of ash, and had a calorific power of 7500.

Required:

(1) The total consumption of fuel per 1000 of zinc obtained.

(2) The efficiency of transfer of heat from the furnace gases to the charge.

Solution:

(1) Zinc charged, per 1000 of zinc obtained

$$1000 \div 0.82 = 1220$$

Ore charged, per 1000 of zinc obtained

$$1220 \div 0.50 = 2440$$

Coal charged with ore

$$2440 \times 0.40 = 976$$

Coal burned in grate

$$2440 \times 2.25 = 5490$$

Total coal used, per 1000 of zinc obtained

$$976 + 5490 = 6466$$

(1)

(2) Calorific power of coal burned

$$5490 \times 7500 = 41,170,000$$

Heat required to raise ore to reduction point

$$2440 \times 159 = 387,960$$

Heat required to raise fuel to reduction point

$$\text{Ash } 98 \times 159 = 15,580$$

$$\text{Carbon } 878 \times 396 = 347,690$$

Total to raise charge to reduction point

$$= 751,230$$

Heat absorbed in distilling away 1000 of zinc

$$= 1,269,000$$

Total heat utilized

$$= 2,020,230$$

Thermal efficiency of utilization of the fuel

$$\frac{2,020,230}{41,170,000}$$

$$= 0.049 = 4.9 \text{ per cent.}$$

(2)

Problem 133.

Natural gas from Iola, Kan., has the following composition:

$$\text{CH}^4 \quad 93 \text{ per cent.}$$

$$\text{H}^2 \quad 2 \quad "$$

$$\text{CO} \quad 1 \quad "$$

$$\text{C}^2\text{H}^4 \quad 1 \quad "$$

$$\text{N}^2 \quad 3 \quad "$$

It is used in a zinc retort furnace, at an efficiency of transfer of heat to the charge of 4.9 per cent, as calculated in Prob. 132, working a charge which absorbed 2,000,000 calories per 1000 kilograms of zinc distilled off.

Required: The volume of natural gas required to be used to displace the anthracite fuel used per 1000 kilograms of zinc produced. The cubic feet of gas per 1000 lbs. of zinc produced.

Solution:

Calorific power of the gas

$$\text{CH}^4 \quad 0.93 \times 8623 = 8009$$

$$\text{H}^2 \quad 0.02 \times 29030 = 581$$

$$\text{C}^2\text{H}^4 \quad 0.01 \times 14365 = 144$$

$$\text{CO} \quad 0.01 \times 3062 = 31$$

$$8765$$

This result may be called calories per cubic meter of gas, or ounce-calories (1°C.) per cubic foot, according to whether it is desired to work in metric units or the English system.

Cubic meters of gas required, per 1000 kilograms of zinc produced:

$$\frac{2,000,000}{8765} \div 4.9 = 4,700 \text{ cubic meters.}$$

$$0.049$$

Per 1000 lbs. of zinc produced:

$$\frac{2,000,000}{0.049} \times 16 \div 8765 = 75,200 \text{ cubic feet.}$$

$$0.049$$

Electric Smelting of Zinc Ores.

In an interesting communication to the American Electrochemical Society (Vol. XII, p. 117), Gustave Gin calculates the electric power necessary for the smelting of several varieties of zinc ore, assuming that the zinc vapor and other gases pass out of the furnace at the usual high temperature— 1200°C.

Mr. Gin makes his calculations of heat required on the basis of molecular weight of zinc compound reduced; that is, for 81 parts of ZnO and 65 parts of Zn . Calculating to 1200° , he finds the heat in the products Zn and CO to be

$$\text{In 65 parts Zn} \dots\dots\dots 26,720 \text{ Cal.}$$

$$\text{" 28 " CO} \dots\dots\dots 8,280 \text{ "}$$

$$\text{Sum} \dots\dots\dots 35,000 \text{ Cal.}$$

whereas we calculate for the same quantities

$$\text{In 65 parts Zn} \dots\dots\dots 37,695 \text{ Cal.}$$

$$\text{" 28 " CO} \dots\dots\dots 8,945 \text{ "}$$

$$46,640 \text{ Cal.}$$

The difference between these numbers is principally in the latent heat of vaporization of zinc, which Gin assumes as

15,370 Calories, but which by a method of evaluation used by the writer figures out 27,070 Calories, and almost exactly the same value has been obtained by a different method by W. McA. Johnson.

Assume then, that we start with cold materials and end with the products of the reaction leaving the retort at 1200° , the sum total of usefully applied heat is the heat of the reaction calculated at ordinary temperature plus the sensible heat of the products at 1200° , or

Heat absorbed by reaction, ordinary temperature.. 84,800 Cal.
Heat in necessary products, at 1200° 46,640 "

Total 131,440 Cal.

To this must be added the sensible heat in the residue left in the retort, to get the total heat which has been applied to the charge. If the charge were pure ZnO, with the theoretical amount of carbon, the residue would be *nil*, but in practice there is always a residue of gangue with unused carbon.

Mr. Gin, having calculated the heat requirement on the above basis, then makes his calculations of power required per ton of ore smelted in the following ingenious way: The weight of each component of 1000 kg. of ore is divided by its molecular weight, and thus the number of molecular weights of material in one ton of ore determined, which, so to speak, gives a kind of chemical formula for the ore. An example will make this clear.

Composition of a calcined calamine zinc ore:

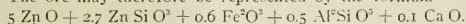
ZnO	40.50 per cent.
ZnSiO ₃	38.07 "
Fe ₂ O ₃	9.60 "
Al ₂ SiO ₅	8.10 "
CaO	2.80 "

If we divide the weight of each compound present by its molecular weight we get the relative number of molecules present in the ore, and the formula for the ore:

KG. IN 1000 KG.

Zn	405 ÷ 81 = 5.0 molecular weights.
Zn Si O ₃	380.7 ÷ 141 = 2.7 " "
Fe ₂ O ₃	96 ÷ 160 = 0.6 " "
Al ₂ SiO ₅	81 ÷ 162 = 0.5 " "
CaO	28 ÷ 56 = 0.1 " "

The ore may therefore be represented by the formula



Assuming that the Fe₂O₃ becomes Fe Si O₃, and that there is to be added enough CaO to form Ca Si O₃ with the rest of the SiO₂ of the zinc silicate, we will need 1.5 CaO to do it, and since there is 0.1 CaO present, 1.4 CaO must be added, which represents $1.4 \times 56 = 79$ kg. of CaO. To form CO with the oxygen combined with the zinc and iron, reducing the latter to FeO, will require:

for 5 Zn O	5.0 C.
" 2.7 Zn Si O ₃	2.7 "
" 0.6 Fe ₂ O ₃	0.6 "

Sum 8.3 C. = 100 kg.

If we use twice the theoretical amount of carbon needed for reduction we have the following balance sheet; weights in kilograms being enclosed:

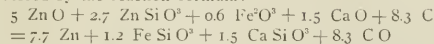
ORE.	ADDED.	CHARGE.
.5 Zn O (405)	.....	.5 Zn O (405)
2.7 Zn Si O ₃ (381)	.....	2.7 Zn Si O ₃ (381)
0.6 Fe ₂ O ₃ (96)	.....	0.6 Fe ₂ O ₃ (96)
0.5 Al ₂ SiO ₅ (81)	.....	0.5 Al ₂ SiO ₅ (81)
0.1 Ca O (28)	1.4 Ca O (79)	1.5 Ca O (79)
	16.6 C (200)	16.6 C (200)

The distribution of this charge will be as follows:

CHARGE.	GASES.	RESIDUE
5 Zn O (405)	5 Zn (325)	..
2.7 Zn Si O ₃ (381)	2.7 Zn (175)	..
0.6 Fe ₂ O ₃ (96)		1.2 Fe Si O ₃ (158)
0.5 Al ₂ SiO ₅ (81)		0.5 Al ₂ SiO ₅ (81)

CHARGE.	GASES.	RESIDUE.
1.5 Ca O (79)		1.5 Ca Si O ₃ (174)
16.6 C (200)	8.3 CO (232)	8.3 C (100)

The essential reactions involved in the reduction are expressed by the reaction formula:



The heat requirements per ton of ore treated may therefore be figured out as:

Decomposition of	7.7 Zn O = $84,800 \times 7.7 = 652,960$ Calories.
" "	2.7 Zn Si O ₃
into Zn O and Si O ₂ =	$10,000 \times 2.7 = 27,000$
Decomposition of 0.6 Fe ₂ O ₃	
into FeO and O =	$64,200 \times 0.6 = 38,520$

Heat absorbed in decompositions 718,480

Formation of 1.2 Fe Si O₃
from FeO and Si O₂ = $8,900 \times 1.2 = 10,680$

Formation of 1.5 Ca Si O₃
from CaO and Si O₂ = $17,850 \times 1.5 = 26,770$

Formation of 8.3 CO = $29,160 \times 8.3 = 222,030$

Heat evolved in formation heats 259,480

Net heat of chemical reactions absorbed 459,000

Sensible heat in 7.7 Zn = $46,640 \times 7.7 = 359,130$

" " 8.3 CO = $8,945 \times 8.3 = 74,240$

" " 8.3 C = $5,760 \times 8.3 = 47,810$

" " 1.2 Fe Si O₃

" " 0.5 Al₂SiO₅

" " 1.5 Ca Si O₃

= 413 kilograms = $460 \times 413 = 300,000$

Sensible heat in products and residue 681,180

Add heat absorbed in chemical reactions 459,000

Total heat requirement of the charge 1,140,180

Important principle: The heat absorbed in an electric furnace by chemical reactions is electric energy utilized at an efficiency of 100 per cent. It is only part of the sensible heat of the materials being treated which is lost by radiation and conduction. Heat losses by radiation and conduction in electric furnace processes should be expressed upon the total energy of the current *diminished by the heat absorbed in chemical reactions*, and not upon the total energy of the current. This principle has been expressed most clearly by Mr. F. T. Snyder, of Chicago, the pioneer electric furnace zinc metallurgist of America.

Expressed thus, electric furnaces give higher efficiencies the greater the absorption of heat in chemical reactions taking place within them. In mere physical processes, such as melting, electric furnaces on a large scale give 75 per cent. net efficiency, with 25 per cent. loss by radiation and conduction. In the above case, figured out for 1000 kg. of zinc ore, 40 per cent. of the total heat requirement is absorbed as chemical heat at 100 per cent. efficiency, and 60 per cent. is needed as sensible heat. This 60 per cent. then represents the net sensible heating effect, and the loss of heat by radiation and conduction must be calculated as one-third of this quantity, and not one-third of the total net heat requirement. We therefore have:

Net heat requirement for chemical reactions.....	459,000
" " " sensible heat	681,180
Loss by radiation and conduction.....	227,060
Gross heat requirement of the furnace.....	1,367,240
Kilowatt hours of current required	

1,367,240

= 1530
860

Mr. Gin's figures have been modified by the writer, as explained above, and anyone consulting his paper on this subject

may make similar modifications to the other cases cited in that paper.

Mr. F. T. Snyder, of the Canada Zinc Company, at Vancouver, B. C., has operated the first practical electric zinc smelting furnace in America. Treating mixed lead and zinc ores, Mr. Snyder uses the furnace and process protected in his United States patents of July 2, 1907. (See this journal, August, 1907, p. 323; December, 1907, p. 489.) The lead is obtained liquid, and the zinc also condensed to the liquid state before leaving the furnace proper, the heat of condensation being partly absorbed by water cooling the condensers and partly by the descending charges, which carry it back into the focus of the furnace. Under these circumstances, Mr. Snyder reports that he has attained unexpectedly low results as to power requirement. It will be recalled, that in discussing the question of the electric smelting of zinc ores in general, and Mr. Gin's process in particular, we assumed the zinc vapor and CO gas to escape from the furnace at a minimum of 1033° C. If, as in Mr. Snyder's furnace, they escape at about 500°, the zinc liquid, the heat in these hot products is reduced very considerably, particularly that in the zinc. Mr. Snyder states in discussing Mr. Gin's paper (*loc. cit.*) that he has smelted pure zinc oxide at an expenditure of 1050 kilowatt hours per 1000 kilograms of oxide. Let us see how this coincides with the theoretical figures:

	Calories.
Heat value of 1050 k.w.-hours	= 1050 × 860 = 903,000
Heat of the chemical reactions, assumed to take place at ordinary temperatures	1000 × 687 = 687,000
Sensible heat in products, at 500°	
Zinc: 800 × 80 = 64,000	
CO: 342 × 152 = 52,000	
	= 116,000

Leaving, by difference, for radiation, conduction and cooling water = 100,000

Mr. Snyder does not give details as to the exact working of his furnace, but his claim to reduce a ton of zinc ore with 1000 k.w.-hours is seen to be a possibility, if he can remove the zinc as liquid zinc from the furnace, not lose too much heat in cooling water, and get most of the heat of condensation of the zinc vapor usefully returned by the descending charges into the working focus of the furnace.

Snyder's furnace, working as claimed, would show a useful efficiency of

$$\begin{aligned} &803,000 \\ &= 0.88 = 88 \text{ per cent.} \\ &903,000 \end{aligned}$$

on the current used, with 12 per cent. losses. The real heat losses, however, should be expressed upon the energy used less that absorbed in chemical reactions, or as 100,000 loss on 216,000 used for sensible heat,

$$\begin{aligned} &100,000 \\ &= 0.46 = 46 \text{ per cent.} \\ &216,000 \end{aligned}$$

This shows that the furnace loses by radiation, conduction and cooling water 46 per cent. of the energy developed as sensible heat in the furnace, but the latter item is only 24 per cent. of the total energy applied to the furnace.

In short, about three-quarters of all the energy consumed by the furnace is utilized in the heat of the chemical reactions produced; of the other one-quarter, half of it is represented by the sensible heat of the products leaving the furnace and half is lost by radiation, conduction and cooling water.

Wiley Dinner.—A complimentary dinner was given to Dr. Harvey W. Wiley on April 9 at the Hotel Astor, New York City, to celebrate the twenty-fifth anniversary of his connection with the Department of Agriculture. Some 200 chemists participated. Mr. William J. Schieffelin acted as toastmaster.

Separating Appliances.

By OSKAR NAGEL, Ph.D.
Filter Presses.

The most important appliance for separating solids from liquids by filtration is the filter press. In its simplest form it consists essentially of a series of chambers, formed either by recessed plates (Fig. 1) or by flush plates with frames between them (Fig. 2). These plates and frames have a lug projecting from each side, the lugs resting on a pair of parallel bars.

One end of each of these bars is secured to the front or head of the press. The plates and frames rest upon them, and

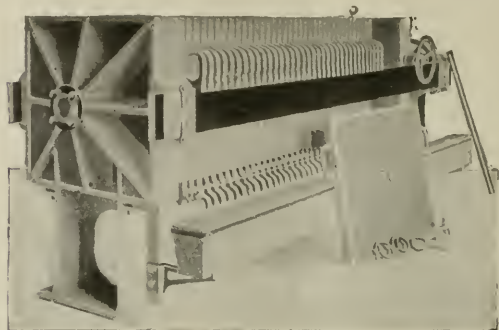


FIG. 1.—RECESSED FILTER PRESS.

the back or follower is forced up against the plates by means of a heavy screw or hydraulic plunger in a yoke or screw standard to which the rear end of each bar is secured.

Over the surface of each plate is stretched the filtering medium, either cloth or paper.

The material to be filtered is pumped in through a channel in the head of the press and is distributed over the surface of the filtering medium, the liquid passing through and out of cored channels in the plates, while the solid material is retained on the surface of the filtering medium, gradually filling the chambers until a solid cake is formed in each. The press is then opened and the cakes are removed. The press is then closed again and the operation repeated.

In the "recessed filter press" the material to be filtered is pumped in through a channel in the center of the head and the filtrate runs out through cocks or bibs provided near the bottom on the sides of the plates. It runs into a trough, which is connected by piping with a suitable receptacle. The advantage of using cocks is that in case a single cloth breaks, that plate may be shut off and the filtration continued.

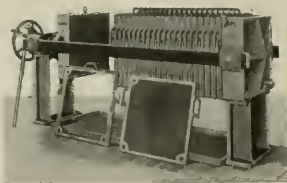


FIG. 2.—FLUSH PLATE AND FRAME FILTER PRESS FOR GENERAL CHEMICAL PURPOSES.

The "flush plate and frame filter presses" have the inlet on one side of the head, instead of in the center, and the material passes along through holes in the handles of the plates and frames. This cored channel is kept from leaking by using rubber collars inserted in the holes of each plate and frame. In this type no holes have to be cut in the cloths.

The thickness of the cake varies from 1 to 6 inches; with materials that are difficult to filter thin cakes have to be produced.

For freeing the cake in the filter press from adhering liquid

particles, most filter presses are provided with a washing arrangement, by means of which the cakes can be washed with water, diluted acids, lyes, benzene, alcohol, etc. For this purpose two extra channels are provided in every filter plate and chamber respectively. The washing liquor enters through one channel and leaves through the other. The former is con-

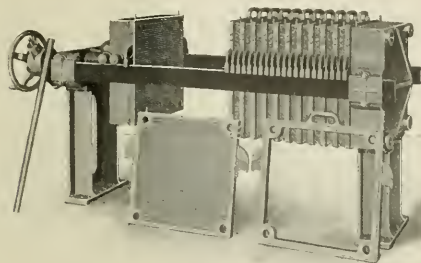


FIG. 2A.—FILTER PRESS FOR VARNISH WORKS.

nected to every second plate only, the cocks of which are closed and the washing liquor passes behind the cloth (i. e., behind the cake) into the press, goes through the first filter cloth, then through the cake and the second filter cloth and leaves finally through the other channel, carrying along the liquid displaced from the cake. The object of washing the cakes is either to produce as pure a solid as possible, or to recover all the liquid.

In certain cases the mass to be filtered has to be kept hot or cold during filtration; hence, for these purposes, channels are cast or coils provided in the plates for the circulation either of hot water or steam or of cold water or a refrigerating mixture. The connection of the channels or coils from cham-

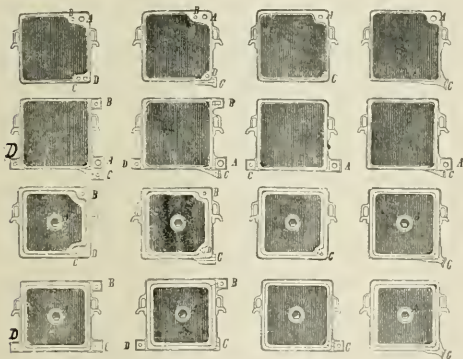


FIG. 3.—ARRANGEMENTS OF CHANNELS IN VARIOUS TYPES OF FILTER PRESSES.

ber to chamber is perfectly tight, so that the mass to be filtered cannot come in contact with the heating or cooling substance.

Heated chambers are used for materials that can be filtered only in molten state (wax, ceresine, etc.) or for liquids from which salts would crystallize out at a low temperature. Cooled chambers are used, if substances are to be separated, which solidify at low temperature only (clarification of cod liver oil, etc.).

In Fig. 3 are shown the most common arrangements of the various channels. A is the channel for introducing the material, B the washing channel, C the discharge of the filtrate

and D the discharge of the wash-water. The 16 cases shown differ from each other with respect to the following four points:

- (1) The filtrate discharge outlets may be closed or open or regulable by means of cocks.
- (2) The chambers may be provided with and without a washing arrangement.
- (3) The method of introducing the washing liquid may be varied.
- (4) It may enter through various pockets. This makes it unnecessary to cut a hole into the filter cloth, so that its life is prolonged by the use of "pocket-shaped" cloths.

The materials used in the construction of filter presses de-

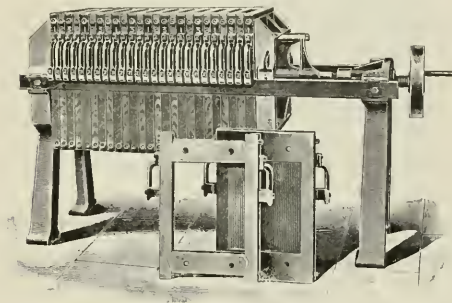


FIG. 4.—WOODEN FILTER PRESS.

pend upon the liquids to be filtered. For liquids which do not attack iron, iron is the best material. For acids, wood (Fig. 4) or hard lead is used; or the iron plates are coated with lead, tin or hard rubber. For very hot acid liquid bronze is generally used.¹

The screw-closing device as shown in Fig. 2 is generally used. The "hydraulic" closing device means simply the transformation of the end of the filter press into a hydraulic press (Fig. 5). An excellent European closing device, which is easily understood, is shown in Fig. 6.

In the recessed filter press the chambers can be tightly closed, as always two cloths are in contact, while in the flush plate and frame filter press the cloth of the plate is in contact with

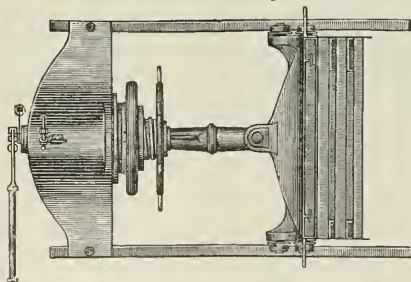


FIG. 5.—HYDRAULIC CLOSING DEVICE.

the metal frame. Hence in the latter type, the frame has to be cleaned and smoothed after every operation.

The recessed plates are stronger and have a longer life than the frames; another advantage of the recessed plate is the wide feed-opening in the center. This absolutely prevents any stopping, while in frame presses stoppages sometimes occur.

The main drawback of the recessed filter press, is the tedious and expensive way of fastening the filter cloth. This incon-

¹ See also the article by Emil Hatschek on materials used in the construction of filter presses, *ELECTROCHEMICAL AND METALLURGICAL INDUSTRY*, Vol. III., p. 220.

venience is done away with in frame presses, as here the cloth is simply laid around the chamber and connected at the bottom end by a few stitches. Another advantage of the latter type

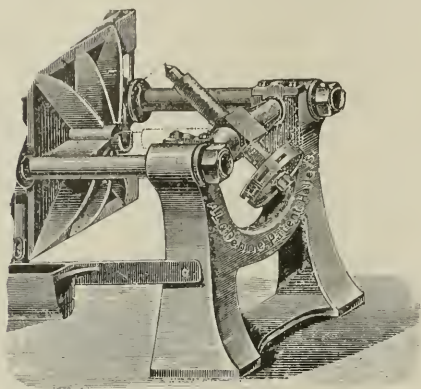
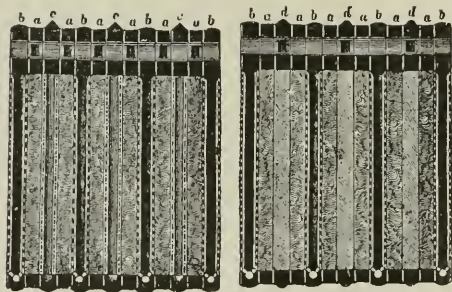


FIG. 6.—CLOSING DEVICE.

is the fact that a cake without a hole in the center is obtained.

For filtering volatile materials the filter press shown in Fig. 2 can be used, since in this type the filtrate is discharged through a pipe at one corner of the head and therefore can be kept from exposure to the atmosphere.

In some cases the filter press is covered by an air-tight sheet-iron cover, which is connected to a receiving or condensing chamber by suitable pipe connections.



FIGS. 7 AND 8.—THREE-CHAMBER PRESS.

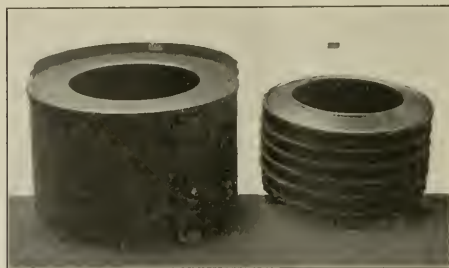
For obtaining perfectly clear solutions—which is quite difficult by the use of filter cloths—A. L. G. Dehne in Halle a. S., Germany, has constructed a so-called three-chamber-press, in which filtration is effected by sand, coal, etc., contained in the press, instead of using cloths. Fig. 7 shows the general arrangement; between two frames *a* a plate *c* is provided, while at the other sides of the frames *a* the plates *b* are arranged. The plates *b* and *c* serve for discharging the liquid during the preparation of the filter. The filtering material—sand, coal, etc.—enters the frames *a* at the top in form of a thin paste and is transformed into a solid cake, while the liquid runs off through the corrugations of the plates *b* and *c*.

After the filter has so been formed in the frames *a* (Fig. 8) the plates *c* are replaced by plates *d*, while the frames *a* and the plates *b* remain in their place. Now the material to be filtered enters at the top at *d*, passes from right to left through the frames *a*, which are filled with sand, coal, etc., and the liquid is discharged perfectly clear through the cock of plate

b. These presses are built of wood and iron, with or without washing arrangement.

A filter press for experimental laboratory purposes is built by most filter press manufacturers.

The most prominent builders of filter presses in the United



FIGS. 9 AND 10.—CENTRIFUGAL BASKET AND DRUM.

States are: The Albright-Nell Company, Bushnell Press Company, J. B. & J. M. Cornell Company, John Johnson Company (Fig. 4), Niles-Bement-Pond Company, William R. Perrin & Company (see this journal, Vol. V, p. 67), Platt Iron Works Company, Robert S. Redfield & Company, T. Shriver & Company (Figs. 1, 2 and 2a), D. R. Sperry & Company, Sweetland Filter Press Company.

Centrifugal Separators.

Another appliance for separating liquids from solids is the

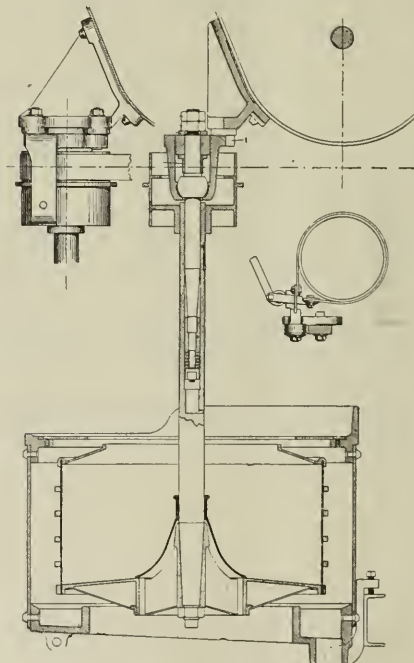


FIG. 11.—CENTRIFUGAL, WITH UPPER DRIVE.

centrifugal. The "basket" containing the liquid and solid substances is rapidly rotated, separation being effected by centrifugal force.

We distinguish centrifugals with upper drive and under

drive. The ones with upper drive require best workmanship and careful operation; though occupying little floor space they have the disadvantage that, on account of the shaft passing

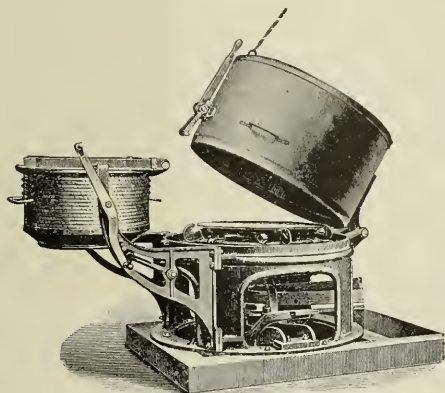


FIG. 12.—BOTTOM-DRIVEN CENTRIFUGAL.

through, the interior of the basket is partly not accessible. This makes the discharging rather difficult. Other disadvantages are the necessity of using heavy foundations and the possibility of impurities getting into the material during lubrication.

Centrifugals with bottom drive occupy more space and have to be provided with a good regulating device; on the other hand they are easily accessible, and do not require a heavy foundation.

According to the material to be treated the interior of the

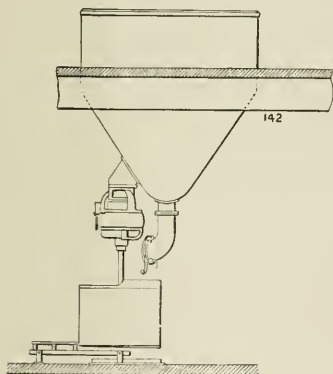


FIG. 13.—ELECTRICALLY-DRIVEN CENTRIFUGAL.

centrifugals is made of copper, steel, wrought iron, bronze, brass, nickel, aluminium, lead, clay or porcelain.

A centrifugal basket, as used by the American Tool & Machine Company, is shown in Fig. 9, the outside drum in Fig. 10. A belt-driven centrifugal (upper drive), built by the same company, is shown in Fig. 11. In Fig. 12 is shown a bottom-driven German centrifugal with movable basket and outside drum.

All belting, shafting and the throwing of oil is avoided by direct connection of centrifugals with electric motors. This method insures rapid acceleration, uniform speed, reduced floor space and extreme cleanliness. Fig. 13 shows (in outline) this type with upper drive as built by the D'Olier Engineering Com-

pany. This same firm also builds direct-mounted-motor under-driven centrifugals (Fig. 14).

It has to be borne in mind that the charge in the basket has to be uniformly distributed before starting the operation.

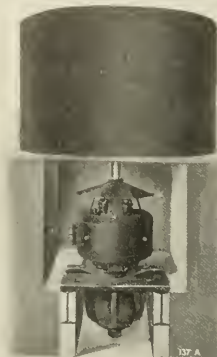


FIG. 14.—DIRECT-MOUNTED-MOTOR UNDERDRIVEN CENTRIFUGAL.

For laboratory or experimental use a 10-inch centrifugal is built by the American Tool & Machine Company.

Finally we want to mention the De Laval centrifugal clarifier which was designed originally for the separation of cream from milk, but is now used for various materials. It is built by the De Laval Separator Company.

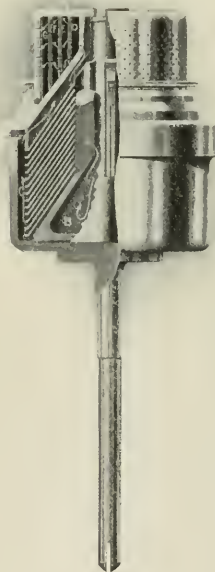


FIG. 15.—CENTRIFUGAL SEPARATOR.

Fig. 15 is a sectional view of that part of the De Laval machine in which the clarifying and filtering is actually accomplished. This is called the bowl, and consists of two separate compartments, which, since their duties are quite different, really perform the work of two independent machines.

The first or lower compartment is the clarifying chamber, the upper the filtering chamber. The clarifying chamber consists of a cylinder filled with a series of cone-shaped pressed-

steel discs, one above the other, about one-sixteenth of an inch apart, and held rigidly in position by a central feeding device, called the "split-wing tubular shaft." The filtering chamber or upper compartment is also cylindrical in shape, but of less diameter than the clarifying chamber. Its side wall contains numerous perforations and is lined with the filter material "H," which may be paper, cloth, wool, etc., as governed by the requirements of the product handled. Within this chamber are placed three concentric cylinders dividing the chamber into four compartments, D, E, F, G. All three cylinders contain numerous perforations and are lined with filter material H. The

liquid first enters the bowl at the point A through the feeding device in the center and drops to the bottom of the clarifying chamber, and is then forced upward by the great centrifugal force and out through the wings of the tubular shaft into the spaces between the discs, which act as so many independent bowls.

In this operation from 90 to 95 per cent of the coarser dirt and sediment is removed and retained in the sediment pockets B and C. After leaving the discs the liquid continues to be forced upward out of the clarifying chamber into the compartment D of the filtering chamber. Here the same centrifugal

force drives the liquid through the walls of the three inner cylinders into compartments E, F and G, the filter material H, with which these cylinders are lined, catching and retaining all the remaining sediment and dirt not removed by the clarifying compartment.

Lastly the liquid is forced through the filter material lining H of the side wall of the filtering compartment itself, and is then delivered into such receptacle as may be waiting for it. This second operation, which consists of forcing the liquid through four independent linings or layers of filter material H, completely removes every last bit of cloud or flock.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Electric-Furnace Reduction of Alumina by Means of Carbon.—

E. Viel, 883,594, March 31, 1908. Application filed Oct. 31, 1906.

To reduce alumina, silica, magnesia, chromite, etc., by means of carbon in the electric furnace, the following conditions are said to be necessary: Raising the temperature approximately to the "decomposition temperature," using the oxide and carbon (charcoal) in very finely pulverized condition and in exact proportion; for instance, according to the equation $Al_2O_3 +$

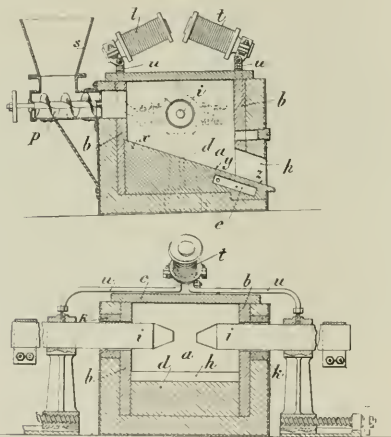


FIG. 1.—ALUMINIUM FURNACE.

$3C = Al_2 + 3CO$; removing the reduced metal (aluminium) immediately from the hot zone into a cold zone (the temperatures of these two zones in the case of aluminium being given as 3000° and 800° C. respectively); continuous operation so as to bring only small quantities of the mixture of oxide and carbon at a time into the excessively hot zone. A furnace for this purpose is shown in cross-section and longitudinal section in Fig. 1. The fushion chamber *a* is provided with carbon walls *b* and a carbon cover *c* and a sole *d* of a very steep inclination (25° to 30°). This sole is water-cooled at its lower end *e*, next to the tapping hole *h*. The powdered mixture is fed into the hopper *s* and introduced into the furnace by the screw conveyor *p*. The two electromagnets *t*, jointed on the legs *u*, exert a repelling effect upon the arc between the electrodes *i* so as to blow it down and bring it nearer to the sole *d*. By

adjusting the ampere turns of one or the other or both electromagnets it is possible to blow the arc into a predetermined zone of the sole (always between *x* and *y* in the upper diagram). The mixture of alumina and carbon drops from the screw-conveyor onto the hottest zone of the sole. Aluminium is reduced, flows off into the cold zone *y,z*, while the carbon oxide escapes upwards. The reduction of silica in this furnace is said to be a more ready operation "because the volatilization temperature of silicon is 1650° , i. e., much higher than that of aluminium, and the difference between the volatilization temperature and the decomposition temperature (2500°) is much less. With this process it is also possible to treat silicates or analogous compounds in order to obtain compounds or alloys, such as silico-aluminium, ferro-chromium, etc. In order to obtain pure aluminium and silicon from silico-aluminium, it is necessary to heat the silico-aluminium to 700° upon the sole of a reverberatory furnace; the aluminium separates and the silicon remains as residue. The aluminium thus formed still contains 3 per cent of silicon; in order to obtain it pure, the silicon is burned like carbon in a Bessemer retort."

Manufacture of Silicospiegel.—E. F. Price, 882,418, March 17, 1908. Application filed Nov. 14, 1905.

The furnace is a vertical stack with downwardly-converging walls and a water-cooled, cast-steel plate at the bottom, forming one electrode. An iron ring at the top of the furnace forms the other electrode. Supported on this is an iron dome with a bell-and-hopper-charging mechanism. The furnace charge consists of a mixture of pyrolusite, silica, iron or iron ore and coke. Initial current paths may be provided between the electrodes to start the operation, but later on the charge itself acts as resistor. The zone of maximum heat is on the hearth in the bottom. The reduced manganese, silicon and iron form a molten alloy which collects on the hearth of the furnace and is withdrawn through a tap-hole. A layer of the alloy solidifies on the water-cooled base-plate and then serves as the lower electrode.

Ferrosilicon.—E. F. Price, 882,417, March 17, 1908. Application filed Nov. 14, 1905.

The furnace is of exactly the same construction as in the preceding patent. The charge is a mixture of silica, iron or iron ore and coke.

Manganese Silicide.—E. F. Price, 882,582, March 24, 1908. Application filed Nov. 14, 1905.

The furnace is of exactly the same construction as in the two preceding patents. The charge is a mixture of pyrolusite, silica and coke.

Ferro-Chrome Free from Slag.—J. B. Huffard, 882,637, March 24, 1908. Application filed July 10, 1907. (Assigned to Electro Metallurgical Co.)

When ferrochrome is made in the electric furnace, the slags

are highly basic and infusible, containing oxides of calcium, magnesium, chromium and aluminium in such proportions that the melting point of the slag is higher than that of the alloy. It is difficult to separate the slag from the alloy. In order to obtain a clean separation the inventor taps the ferrochrome and the slag from the furnace into a pot having a lining. The heavier alloy subsides and the superincumbent slag quickly solidifies or stiffens; while the metal beneath remains molten. The taphole in the bottom of the pot is then opened and the molten ferrochrome is run out into the ingot mold. The solid body of slag is then discharged from the pot, which is relined for future use.

Calcium Carbide Furnace.—E. Appleby, 882,733, March 24, 1908. Application filed March 20, 1906.

The furnace consists of a crucible formed of two vertically-disposed cylindrical receptacles telescoping with each other, the upper receptacle being open at the bottom. A pair of electrodes extend into the crucible at the lower end of the upper receptacle which serves as a hopper for delivering the material to the zone of activity between the electrodes. The lower receptacle is open at the top and closed at the bottom and forms a container for the completed carbide. The lower receptacle can be withdrawn downwardly away from the electrodes and the upper receptacle and can also be disconnected from its lifting mechanism, to be withdrawn toward one side and then tilted for discharging its contents.

Electric Furnace.—H. L. Hartenstein, 883,110, March 24, 1908. Application filed Nov. 30, 1906.

Mechanical details of construction of a gas-tight electric furnace with movable and adjustable electrodes. The hearth or melting pot is supported upon a truck so that it can be easily removed. When in use the upper edges of this pot fit closely with the lower edges of the downwardly converging walls of a closed upper compartment so as to make an air-tight joint.

Within the upper compartment two electrodes are provided which can be raised and lowered at will by means of certain mechanism controlled from the outside.

Electric Furnace.—A. L. Marsh, 882,788, March 24, 1908. Application filed Sept. 19, 1907. (Assigned to Hoskins Co.)

3 in Fig. 2 is a casing of magnesite or fire-brick, with a cover 4 of asbestos-board. The furnace lining 14 forms at the same time the resistor and is made up of separate rings 15 of carbon in contact with each other, the top ring 16 and the bottom plate 17 being made of graphite and having terminal posts 18 and 19. The central opening is the heating chamber. By turning the screw 12 in one direction

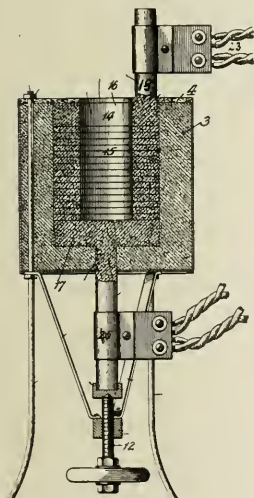


FIG. 2.—RESISTANCE FURNACE.

or the other, the register sections, which are compressed between it and the cover 4, will be loosened or tightened as to their surface contact with each other, so as to increase or decrease the resistance of the resistor. The rate of heat production and therefore the temperature may thus be easily controlled. (A description of the commercial type of this furnace will be found on another page in this issue.)

Induction Furnace.—K. A. F. Hiorth, 883,311, March 31, 1908. Application filed Nov. 20, 1906.

The object is to so arrange the primary inducting coil as to permit it to be used alternately or simultaneously for two or more furnaces. Claim 1 refers to "the combination with a plurality of furnaces, of a magnetic circuit common to all of them and a single magnetizing coil for said circuit." The arrangement adopted was already illustrated in our last issue, page 143, the first diagram of Fig. 2.

Electrolytic Furnaces.

Aluminium-Magnesium Alloys.—F. Von Kugelgen and G. O. Seward, 881,934, March 17, 1908. Application filed April 27, 1905. (Assigned to Virginia Laboratory Co.)

The electrolyte consists of magnesium oxide dissolved in magnesium-lithium fluoride (or a mixture of magnesium fluoride and the fluoride of a more electropositive metal). The cathode is molten aluminium. The magnesium, set free at the cathode, alloys with the aluminium. Magnesium oxide is fed continually into the electrolyte to replace that which is decomposed. Instead of dissolving simply magnesium oxide in the fluoride bath, both aluminium oxide and magnesium oxide may be dissolved in the bath and an alloy of aluminium and magnesium directly set free at the cathode. Instead of magnesium oxide magnesium oxychloride may be used.

Production of Aluminium.—H. S. Blackmore, 881,049, March 3, 1908. Application filed Oct. 29, 1904.

The electrolyte is a mixture of aluminium oxide and aluminium fluoride, to which calcium chloride may be added to increase the fluidity. The electrolyte is fused by the passage of the current. Soluble anodes are used, consisting of aluminium carbide (Al_4C_3 , aluminium methide). Aluminium is set free at the cathode, while oxygen and fluorine are liberated at the anode and immediately combine with the aluminium carbide to produce carbonic oxide (which escapes as gas) and aluminium fluoride which passes into the electrolyte. The aluminium carbide anodes must be replaced from time to time.

Electrolytic Processes.

Nickel and Copper from Ores and Matte.—E. Günther and R. Franke, 875,259, Dec. 31, 1907. Application filed June 18, 1907.

Garnierite and magnetic pyrites containing nickel and copper are smelted together so as to form matte or concentrated nickel or nickel-copper regulus. It is important to take care that the iron which may be contained in the ore is converted into slag as far as possible. The copper-nickel is subjected to electrolysis as anode in copper sulphate, containing free sulphuric acid; a copper sheet forms the cathode. At the anode iron, copper and nickel are dissolved, while the precious metals, sulphur, silicic acid, small portions of metallic sulphides, etc., form the anode slime. The latter is washed out, dried and treated with a suitable solvent for the sulphur. The residue is slightly roasted so as to obtain the copper, nickel, iron, etc., as oxides and the silver as sulphate. The residue is then treated with the spent electrolyte, whereby the free acid is neutralized and the oxides are converted into sulphates. The insoluble remaining portion, containing silver, gold, small portions of sulphides, sand, etc., is then treated to extract the precious metals. The sulphate-containing solution is treated with copper tailings to deposit the copper contained therein. The other metals are separated by fractional crystallization and chemical deposition. The last traces of copper are eliminated by nickel sponge. One obtains a technically pure sulphate of copper and nickel sulphate free from copper.

Since more copper is deposited on the cathode than is dissolved from the anode, it is necessary to add regularly new copper sulphate to the electrolyte. The latter becomes, of course, more and more rich in nickel. It is finally drawn off and partly used for treating the anode slime. From the rest the copper is extracted by evaporation, crystallization and subsequent electrolysis with insoluble anodes. The remaining liquid, which contains nickel sulphate, much sulphuric acid, a

small proportion of iron salts and other impurities, is neutralized with NiO ; the impurities are chemically eliminated. A solution of pure sulphate of nickel is obtained, which is electrolyzed with insoluble anodes.

Nickel and Copper from Ores.—E. Gunther and R. Franke, 879,633, Feb. 18, 1908. Application filed June 18, 1907.

Magnetic pyrites containing nickel and copper are converted into matte and the copper-nickel regulus produced is subjected to the action of chlorine either (1) in the form of gas or (2) in *statu nascendi*. (1) The ground copper-nickel regulus is introduced into a closed drum together with a solution of a chloride, such as sodium chloride, calcium chloride, etc., and treated with chlorine gas. If the temperature is regulated so as not to rise too much, the sulphides of the metals are converted into chlorides or subchlorides, while at the same time sulphur is set free. The solution is then filtered and freed from impurities and the resulting nickel-copper solution is electrolyzed with insoluble anodes. Copper is deposited at the cathode, while at the anode chlorine is developed. The electrolyte becomes poorer in copper during electrolysis. Therefore, fresh copper-nickel solution is added until the contents of the bath in nickel reaches a certain concentration. Then the copper is removed by electrolysis and its last traces by chemical precipitation. The resulting sub-chloride of nickel solution is electrolyzed yielding nickel and chlorine. (2) If the chlorine is used in *statu nascendi*, the copper-nickel regulus is used as anode in an electrolyte of a hydrochloric solution of copper chloride in mixture with an alkali or earthy alkali chloride, while a sheet of copper forms the cathode. Chlorine is evolved at the anode which converts the sulphides into chlorides liberating at the same time sulphur, and so on essentially in the same way as before.

Tin from Tin Scrap.—F. von Kügelgen and G. O. Seward, 883,139, 883,140 and 883,141, March 24, 1908. Application filed June 10, 1907.

According to 883,139 tin is recovered from tin scrap by a cyclic process, consisting of two steps. In the first step tin is removed from the scrap by means of anhydrous chlorine, yielding anhydrous stannic chloride. This is converted in the second step into an electrolyte by dissolving it in water and is electrolyzed, yielding tin and chlorine. The latter is dried and used to treat a second charge of scrap. The electrolysis is carried out, according to 883,140, in a diaphragm cell, but the electrolysis is not carried so far as to cause the stannic hydroxide to precipitate in the anode compartment (due to hydrolysis). Before this result occurs and when the current-density begins to notably drop, the electrolyte is discharged from both compartments of the cell, the anolyte containing stannic hydroxide and catholyte containing hydrochloric acid are mixed, and the mixture is concentrated by boiling it down to a density of about 1.4° to 1.5° Beaume, whereby the stannic hydroxide and hydrochloric acid are combined with the production of stannic chloride. The resultant solution is then returned to the electrolytic cell. A diaphragm cell is used, with an aqueous 20 per cent. solution of hydrochloric acid in the anode compartment (which may contain a small amount of stannic chloride) and a stannic chloride solution of specific gravity 1.2 in the cathode compartment. The cell is made of slate, the diaphragm of porous earthenware, the anodes of graphite and the cathodes of sheet tin. A cathodic current density of 4.2 amperes per square decimeter is used. As the electrolysis proceeds, the relatively high ionic velocity of the hydrogen cation causes a gradual transfer of hydrochloric acid from the anode to the cathode compartment, until finally the current-efficiency begins to notably drop. At this stage the catholyte may contain about 18 per cent. of hydrochloric acid and a little stannic chloride. Both solutions are thereupon removed from the cell and the old catholyte is transferred to the anode compartment, its hydrochloric acid content being brought up to 20 per cent. by the addition of acid. Stannic chloride is added to the old anolyte

until its specific gravity rises to 1.2 and it is then placed in the cathode compartment. The initial cell conditions are thereby restored and the electrolysis is resumed.

Pure Tin from Tin Dross or Waste.—A. J. M. Thiriot, 883,589, March 31, 1908. Application filed March 22, 1907.

The object is the electrolytic extraction of pure tin from stanniferous slimes, or from tin dross, or tin waste, or old tin plate, or from natural tin ores which have undergone an energetic oxidizing roasting and lixiviation. If the product treated is bronze, nearly all of the tin derived therefrom is found in the form of stannous hydrate, which it is advisable to preliminarily transform into stannic hydrate. This oxidation takes place after washing the slimes, being effected naturally, at the surrounding temperature, in the course of exposure of the slimes to the air, with a view to their desiccation, by atmospheric action. The process is carried out in three steps. The first step is the formation of a solution of stannate of sodium. The hydroxides of tin are treated at the boiling point with a 10 or 12 per cent solution of caustic soda in iron vessels; one liter of a 12 per cent caustic solution dissolves from 45 to 50 grams of tin. The mixture is maintained at the boiling point for about 1 to 1½ hours and is to be stirred during ebullition. Several vessels are employed to methodically enrich the liquor. Impurities entering into solution are antimony, arsenic, copper and lead. Antimony becomes antimonic acid of sodium, but in the course of electrolysis is changed into antimoniates, which precipitates. Arsenic forms arsenite, which becomes arseniate and accumulates in the liquor. The precious metals remain in the waste. The second operation consists in the purification of the stannate solution from copper and lead. The solution is heated to 70° C. and a concentrated solution of sodium sulphide is added whereby copper and lead are precipitated. The third step is the electrolysis of the purified solution, which is carried out in an iron tank with insoluble anodes of iron and cathodes of sheet tin or tin plate. The electrolyte is kept at a minimum temperature of 80°. The voltage is 2.4 and the current density 300 to 400 amperes per square meter of cathode, a single side only being counted. Twenty-five volts may be easily placed in series. The electrolyte is held sufficiently concentrated in stannate of sodium and is maintained in a fairly active circulation. The tin deposit is of a clear gray color and very adherent and coherent and is stated to contain less than 0.1 per cent impurities. If the current density is not too high, 0.8 gram of tin may be obtained per ampere-hour. (According to our Vol. V., p. 375, where this process was already described, the same is stated to be in commercial use in France.)

Electrodeposition of Iron.—S. O. Cowper-Coles, 884,075, April 7, 1908. Application filed Sept. 16, 1907.

Iron can be deposited in a form suitable for the production of tubes, sheets and wire, with a bright smooth surface resembling that of very highly polished iron, by maintaining the solution charged with iron oxide in suspension. Excellent results are obtained with a solution containing 20 per cent. of sulpho-cresylic acid saturated with iron, the current density being 100 amperes per square foot of cathode surface, the voltage 3.25 at the terminals of the iron electrodes, these being one-half inch apart and the temperature of the electrolyte 70° C. The temperature of the electrolyte considerably affects the quality of the iron. If it is much below 70° C. the iron becomes laminated and flakes off; if it is much above 70° C. the surface becomes covered with ridges or stream lines and cannot be used for commercial purposes without further treatment. "The sulpho-cresylic acid above mentioned is a cresol-sulphonic acid containing approximately 108 parts cresol and 98 parts sulphuric acid. The cresol contains ortho 35 per cent, meta 40 per cent, and para 25 per cent. This cresol is heated with sulphuric acid, yielding isomeric cresol-sulphonic acids." It is important that none of the oxide in suspension shall be deposited on the iron, otherwise it will be worthless for com-

mercial purposes. It is therefore advantageous, in producing sheets or tubes, to slowly revolve the cathode which may be arranged longitudinally or vertically. This also insures an equal thickness of deposit by changing the relative position of the anode and cathode. The iron produced from the sulphocresylic solution is exceedingly hard and when it is desired to produce soft tough iron, ferrous sulphate solution should be employed. It may be advantageous to add small quantities of carbon bisulphide from time to time to the electrolyte. "Iron articles produced as described above do not pit or corrode like iron which has been cast or wrought into the desired form, and this is probably due to the purity and uniformity of the metal." When requiring to produce steel articles "carbon is deposited with the iron" and after removal from the mandrel they are heated to a high temperature to convert the iron into a steel. In starting with iron carbonate or sulphide ore, the ore is roasted and mixed with crushed coke so as to form a filter bed and sulphuric acid solution is passed through the filter bed. The coke and iron oxide form an electric couple in the presence of the acid, thus facilitating the dissolution of the iron oxide. An external source of current may also be employed.

Recovery of Metals from Dilute Solutions.—S. B. Christy, 883,170, March 31, 1908. Application filed March 10, 1906.

The object is to recover gold, silver, copper from the very dilute solutions which result from the extraction of the metals from ores, whether these solutions be acid or alkaline, and whether the metals be combined as chlorides, sulphates, bromides, cyanides, etc. In order to recover the metals in a reasonable time, it is necessary to have numerous cathode surfaces of enormous area, and a similar number of anodes, but of smaller area, and to circulate the solution so as to bring it into intimate contact with anodes and cathodes in rapid alternation so as to maintain a constant supply of metal at the cathode for the electric current to precipitate. All the electrodes are made pervious and the solution is passed from one end of the cell through the series of electrodes to the other end of the cell. An arrangement similar to the series system for copper refining is employed; only the first anode and the last cathode being connected to the external circuit, while all intermediate electrodes ("compound electrodes") act as bipolar electrodes, one side being cathode, the other anode. To protect the anode side against the corrosive action of the electrolyte, it is made of artificial graphite, with perforations of an angle of 45°. The cathode side, which receives the metallic deposit, may be made of wire cloth or fragments of graphite, etc., held by cheesecloth in close contact with the anode side. Other constructions of the "compound electrodes" are also described. For instance, "coke whiskers" (an occasional product of coke ovens) is very suitable for receiving the metal deposit. Common charcoal is also very suitable if made an electric conductor by heating it to a yellowish or white heat. It becomes a better conductor when charred under pressure and by the addition of small amounts of such substances as rosin, asphaltum, bitumen, etc. Charcoal in filament form made from "excelsior" is excellent.

Precipitating Gold.—John E. Greenawalt, 876,346, Jan. 14, 1908. Application filed April 3, 1905.

The object is to precipitate gold and silver from chloride solutions produced in the chlorination process. The precipitation is carried out at a temperature of 130° F. or more in a cell constructed as follows: In the lower part of the cell is placed a perforated floor on which sponge or shavings of lead, with from ½ to 1 per cent of zinc, are placed. The shavings are cut about one-sixteenth of an inch wide and a hundredth of an inch thick. In the upper part of the cell a porous jar is provided containing the carbon anode. The metallic shavings on the perforated bottom form the cathode. The solution is introduced into the cell near the bottom and just below the perforated floor. It then flows upwards and through the shavings. The cathode deposit is a black pulverulent slime consisting principally of lead, silver and gold, which is melted into bullion and the

metals separated. The recovered lead is melted and a small amount of zinc is added, after which it is cut again into shavings. With a depth of 6 inches of shavings a current of five amperes for every cubic foot of shavings is recommended.

Diaphragm Cell.—W. H. Rines, 878,425, Feb. 4, 1908. Application filed June 17, 1907.

This diaphragm cell, which is intended for sodium chloride electrolysis, is shown in Fig. 3; 12, 13 are the graphite anodes, while 2 is the perforated cathode having deep corrugations of V-shape. The object of the construction of the cathode is to cause the caustic formed to move by gravity from the sphere of electrolytic action so that it falls away freely from the cathode plate as rapidly as formed, thus preventing a dif-

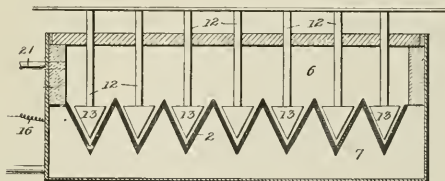


FIG. 3.—DIAPHRAGM CELL.

fusion into the anode chamber. The cathode is perforated and the top is coated with an insulating paint. A diaphragm conforming with the corrugations of the cathode, in form of a sheet of asbestos paper, is placed above the cathode plate. The sodium hydrate falls to the bottom of the tank. 6 is the anode compartment filled with sodium chloride, and 7 is the cathode compartment filled with water up to within about an inch of the cathode plate. "A liquid, inert to the products of electrolysis, is poured over the water and serves to prevent the carbon dioxide in the air from acting on or carbonating the caustic soda solution in the bottom of the cathode chamber and also has a balancing medium to retard diffusion."

Anode for Chloride Electrolysis.—M. Ruthenburg, 882,169, March 17, 1908. Application filed Sept. 20, 1901.

A chlorine-resisting electrode is "formed of a compound comprising silicon and another substance which is a conductor of electricity, such as metallic copper, carbon and the like, capable, *per se*, of resisting the action of chlorous acid." An alloy containing from 10 to 25 per cent of silicon is recommended.

Production of Chromic Acid.—M. LeBlanc, 883,651, March 31, 1908. Application filed Jan. 13, 1906. Assigned to Badische Anilin & Soda Fabrik.

The object is to produce chromic acid by anodic oxidation from chromium compounds of a lower degree of oxidation and particularly to regenerate chromic acid solutions which have been used for oxidizing purposes; for instance, for the production of anthraquinone from anthracene. A diaphragm cell is used, but the diaphragm does not extend to the bottom of the cell. The solution to be oxidized is introduced at the bottom of the cathode compartment. The electrodes are made of hard lead. The best results are obtained often only after a considerable period (for instance, 14 days) of undisturbed working.

Anode Support for Electroplating.—A. M. Hill, 882,110, March 17, 1908. Application filed April 15, 1907.

Mechanical details of a suspension arm for an electroplater's anode to enable an easy separation of the support from the anode and the convenient insertion of a new anode. The anode has a head formed with a flat transverse horizontal face which is at right angles to the longitudinal axis of the anode and is formed with side faces below the flat face. These side faces are inwardly inclined at an angle to the flat face and are likewise longitudinally inclined, so that the head partakes of the form of a double wedge shape. The supporting hook has a socket at its lower end which is adapted to engage

the wedge-shaped head of the anode. This socket contains a flat side which rests on the flat face of the head and also is formed with lateral flanges interiorly inclined in two directions so as to correspond to and engage with the double inclination of the sides of the head. The whole arrangement is so that an interlocking of the socket with the head may be effected when the two parts are connected together, the interlocking being of such a character as to prevent the hook from being disengaged from the anode except when moved in a particular direction for that purpose.

Electrotypes.—S. O. Cowper-Coles, 875,784, Jan. 7, 1908.

Application filed March 5, 1906.

The interior of a circular vat is fitted with a framework of wood or other suitable material adapted to receive the trays or cases filled with wax forming the cathodes upon which the impressions are made for electrotyping. A frame is suspended in the center of the vat in such a manner that it can be rotated; it carries the copper anodes, which are perforated to permit of the free circulation of the electrolyte. The electrolyte is introduced through the bottom or center of the vat by means of a pump and is projected by centrifugal force into the molds on which the metal is to be deposited so as to remove any air bubbles that may be retained in the recesses thereof. In order to free the electrolyte from suspended matter, it is forced by the pump through a filter.

Electric Discharges Through Gases.

Nitric Acid from Air.—H. Pauling, 882,958, March 24, 1908.

Application filed Aug. 12, 1902. Assigned to Westdeutsche Thomsphosphat-Werke.

The feature is the combination of an electric furnace with a regenerative gas-furnace. The furnace consists of a heating chamber in which the arc discharge takes place, and one or more pairs of heat regenerators surrounding the heating chamber. The air after having gone through the arc discharge, passes through the regenerators and is then subjected to steam to produce nitric acid. A fresh supply of air is then heated by the regenerators, etc.

Ozonizer.—A. C. Wood, 882,509 and 882,510, March 17, 1908.

Applications filed Oct. 18, 1904.

Through a tubular electrode of copper, lined inside with nickel, extends a nickel-plated rod, coaxial with the tubular electrode, but insulated from it. The rod in the center is slotted longitudinally, so as to carry pointed combs from which a brush discharge passes off; or nickel brushes of circular or disk form are sleeved on to the rod so as to produce the brush discharge. The air to be ozonized is passed through the space between the tubular electrode and the rod in the center.

Batteries.

Storage Battery Plate.—W. Gardiner, 874,841, Dec. 24, 1907.

Application filed April 26, 1906.

Claim 2 refers to "a storage-battery plate comprising a bar, a spacing-member mounted on said bar, a receptacle having a transversely slotted bottom and adapted to contain active material, and mounted on said spacing member, an absorbent sheet mounted between each of said receptacles and said spacing-members, and a frame cast integral with each of said members after the same have been assembled."

Storage Battery.—W. Gardiner, 877,889, Jan. 28, 1908. Application filed May 2, 1905.

The fifth claim refers to "a grid comprising oppositely disposed series of horizontal containing bars of a triangular cross-section set with apex outward, and a series of oppositely disposed vertical strengthening bars, each bar being provided with a series of inwardly flaring lugs or teeth, the teeth of oppositely disposed bars being in staggered relation to each other."

Storage Battery.—W. L. Merrin, 882,573, March 24, 1908. Application filed Oct. 5, 1896.

The containing vessel is made of corrugated sheet iron

which forms one electrode, while within the cell there are a series of corrugated iron sheets forming the other electrodes. The latter are so bent as to firmly hold and enclose the active material consisting of red lead. An alkaline electrolyte is used. In charging, lead is deposited on the negative electrode, while the active material of the positive electrode is oxidized to a higher oxide.

Storage Battery.—T. A. Edison, 880,978, March 3, 1908. Application filed Nov. 2, 1905. Assigned to Edison Storage Battery Co.

The first claim refers to "an electrode element, comprising a perforated inclosing pocket, non-deformable under normal working conditions, containing a highly compressed mass of active material and a network of conducting paths, formed of overlapping flakes, extending throughout the active mass and in contact with the pocket walls and with which the particles of active material are deformably compressed into intimate contact."

Storage Battery.—T. A. Edison, 880,979, March 3, 1908. Application filed Nov. 2, 1905. Assigned to Edison Storage Battery Co.

The first claim refers to "the method of making electrode elements which consists in introducing a mixture of particles of active material and flake-like conducting material within non-deformable inclosing pockets, and in applying a pressure to such material sufficient to crush or deform the active particles and cause them to substantially follow the contour of the conducting flakes."

Storage Battery.—T. A. Edison, 882,144, March 17, 1908. Application filed March 30, 1905.

Claim 25 refers to "a storage-battery electrode, comprising a sectional inclosing pocket having perforated walls, the sections of which are welded together, a multitude of conducting metallic flakes within the pockets, said flakes being welded together and to the pocket walls to form an integral conducting sponge-like or cellular structure and active material carried within the cells thereof."

Storage Battery.—J. W. Aylsworth, 880,957, March 3, 1908.

Application filed April 28, 1905. Assigned to Edison Storage Battery Co.

The patent refers to the production of nickel hydroxide as used as active mass in the Edison battery. The feature of the invention is that hydrated peroxide of nickel, $\text{Ni}(\text{OH})_2$, can be formed in and plated out of a cyanide solution electrolytically at the anode.

RECENT METALLURGICAL PATENTS.

Iron and Steel.

Converter Process.—Alexandre Tropenas, the French metallurgist, best known through his modification of the Bessemer converter, patents a method of carrying out the converter process, suitable for comparatively small charges (880,253, Feb. 25, 1908). In order to produce sufficient heat to have the metal in fluid condition, he adds silicon, the heat of combustion of which yields the necessary temperature. This method presents the following difficulties: If silicon is added before the appearance of the carbon flame, it retards and prolongs the first period of the process which comprises the time from commencement of the blow to the time when the carbon flame appears; the result is that the lining is worn away and a bad operation is produced. If on the other hand silicon is added near the end of the operation at about the moment of the dropping of the carbon flame, the operator is deprived of the reliable signs furnished by the flame for the stoppage of the operation at the right moment so that it is exceedingly difficult to get the required rate of steel. Mr. Tropenas starts with a hematite pig iron containing as little silicon as possible. If such low silicious iron cannot be obtained, a mixture of pig iron and steel scrap may be charged in the cupola so as to

lower the percentage of silicon in the metal poured into the converter. On account of the low percentage of silicon the first period of the blow is very short. As soon as the second period begins, that is immediately after the appearance of the carbon flame at the mouth of the vessel, a small quantity of silicon (about 5 per cent), in the form of highly silicious pig iron or ferrosilicon, is added and the blowing is continued without stoppage of any sort until the flame drops. This drop is very characteristic and very clear. The steel contains no trace of the supplementary silicon which has been added and is not overoxidized. The final addition of ferro manganese is then made in the usual way and the steel is ready to pour into molds. It is stated that experience has shown that by this process with a converter of a half-ton capacity only it is possible to always obtain the same percentage of carbon and the same quality of metal without appreciable practical variation, and that the steel is sufficiently fluid to be carried in small ladles and to be poured into very small molds.

Modified Converter Process.—E. von Maltitz (879,480, Feb. 18, 1908) proposes to purify iron in a revolving vessel of egg form as shown in Fig. 1. The interior of the vessel 2 is provided with a refractory basic or neutral lining 26, and the trunnions are hollow to provide inlet and outlet passages 27 and 28. The blast pipe 29 terminates in a nozzle 31 which is so directed as

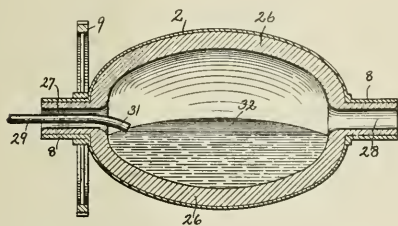


FIG. 1.—MODIFIED CONVERTER PROCESS.

to cause the blast to switch horizontally through the vessel across the surface and imping against that wall which rotates upwardly. After a charge of melted iron has been introduced, together with enough burnt lime to insure the production of a strongly basic slag, the apparatus is set in rotation (from 10 to 40 revolutions per minute for a vessel treating 15 tons of metal). The air-blast is then turned on, and on account of the direction of the nozzle noted above, the air blast impinges on the surface of the metal where it is freed from slag by centrifugal force. The blast traverses the length of the vessel and passes out through 28. The silicon and carbon are first oxidized with considerable evolution of heat; and with steadily rising temperature, a liberal quantity of the basic slag forms which eliminates the phosphorus. The process differs from the Bessemer converter, as the air is not blown through the metal, and it differs from the Tropenas converter by much more rapid operation on account of the rotation of the vessel. The rotation continually exposes fresh surfaces of metal from beneath the slag; further under the centrifugal action the impurities which are specifically lighter than pure iron are driven toward the axis of rotation of the vessels, viz., to the surface of the bath where their elimination takes place. The constant and thorough agitation also facilitates the elimination of occluded gases. When the slag contains enough iron oxides to act as a purifying agent, the blast is interrupted or restricted, in order to recover to a greater or less extent the iron in the slag. The slag may then be drawn off, and the metal recarburized and converted into steel, the rotation of the vessel insuring a perfect mixture.

Chilling Cast Iron.—Carborundum has been used in the past in the steel industry as a substitute for ferrosilicon, but a new and interesting application is proposed by Mr. R. C. Totten

(881,036, March 3, 1908). Chilled castings are generally made from charcoal pig iron on account of the quantity of combined carbon contained in it. Mr. Totten now produces chilling cast metal from pig iron made by the coke and coal process, with the aid of silicon carbide (carborundum). The coke or coal iron is melted in an air furnace and the proper proportion of silicon carbide is added to produce the proper depth of chill, carborundum continuing some 30 per cent. C.

Blast Furnace Slag for Cement Making.—F. W. Wood (883,770, April 7, 1908) proposes a modified and less expensive procedure in treating blast-furnace slag. To secure the crystalline state essential to the highest cementing qualities, the slag must be held for some minutes in a pasty condition. For this purpose the molten slag is delivered into an inclined revolving tube or barrel through which it passes from end to end. This tube is cooled artificially by water from the outside. The slag is thereby divided into pasty nodules, which tumble over and over in contact with one another. The size of the nodules is governed by the rate of rotation and the rate of cooling. By the gradual cooling a "molecular condition" is obtained which is claimed to be preferable for cement-making purposes to the vitreous condition produced by the sudden cooling employed in ordinary practice. In some cases it is advantageous to subject the mass, while cooling, to the action of a strong current of air. The slag, as it leaves the blast furnace, contains from 1½ to 3 per cent. of sulphur in form of calcium sulphide, which is highly objectionable in cement, since in contact with air it slowly oxidizes to calcium sulphate with resulting disintegration of the mortar. By the exposure of the highly heated slag to the oxidizing effect of an air draft, a considerable portion of the sulphurous contents is oxidized within the barrel with the formation of calcium sulphate, which is not objectionable in cement.

Gold and Silver.

Cyanide.—Low-grade, highly refractory sulphide ores are treated by the cyanide process in the following way, devised by J. E. Porter and A. L. Clark (880,821, March 3, 1908): The crushed ore, mixed with the cyanide solution, is placed in a tank having a false bottom of a porous material like earthenware. Porous cylinders of earthenware are inserted within the mass of the ore. Compressed air is then driven through the pores in the false bottom upward into the ore mass and also from the inside of the porous cylinders through the pores into the ore mass outside, so that the whole mass is constantly agitated by forcing through it very minute bubbles of air, which aids in the effect of the cyanide solution. The mass is simultaneously heated and an addition of an alkaline earth oxide is made to neutralize any acidity. After the metallic values have been extracted by the solution the air pressure is withdrawn from the cylinders and suction is now applied through the cylinders, thereby filtering the solution containing the metallic values into the porous cylinders and withdrawing them to an outside reservoir. At the same time compressed air is still forced through the false bottom in order to agitate the slimes and prevent them from adhering in muddy layers on the outside surfaces of the cylinders.

Chlorination.—G. Gurney, of Berkeley, Cal. (871,766, Nov. 19, 1907), proposes to extract gold and silver from sulphide ores by a treatment in a saturated solution of common salt containing 6 per cent. ferric chloride and 1 per cent. hydrochloric acid. The ferric chloride is reduced to ferrous chloride with simultaneous formation of gold and silver chlorides. The solution is then electrolyzed, precipitating gold and silver on the cathode and oxidizing the ferrous to ferric chloride at the anode.

Chlorination.—John E. Greenawalt, of Denver, Colo. (873,309, Dec. 10, 1907), endeavors to avoid metallic losses in chloridizing roasting. One-half to one per cent. of common salt is added to the ore in the roasting furnace so as to act upon the

baser elements in the ore. The red-hot ore is then introduced into a gas-tight chloridizing chamber, where it is subjected to a stream of chlorine gas which chloridizes the precious metals and converts them into soluble chlorides. The ore passes downward and through an artificially cooled zone, where most of the volatilized fumes are precipitated. The escaping gases and steam caused by moistening the ore in the screw conveyor (which leads from the bottom of the chloridizing chamber to the roasted-ore ear) are passed into a condensing chamber, where the remaining values contained in the gases are completely precipitated.

Filter.—H. W. Blaisdell and H. A. Brooks, of Los Angeles, Cal. (875,687, Jan. 7, 1908), describe a filter leaf with passage-ways of sufficient capacity to permit rapid and uniform filtration

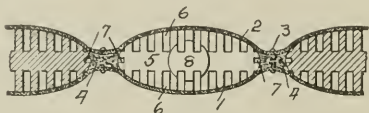


FIG. 2.—FILTER CONSTRUCTION.

over the entire surface; 1 and 2 in Fig. 2 are sheets of fabric sewed together at 3, where 4 are strips of foraminous material; 5 are distenders with grooves 6 and 7. At the lower end of the filter leaf a perforated pipe is provided into which the liquid runs from the grooves 6 and 7 and is then discharged.

Copper and Nickel.

Smelting Copper-Nickel Sulphide Ores.—J. T. Carrick and S. Pattison (882,234, March 17, 1908) treat pyritic copper or nickel or copper-nickel sulphide ores, which are poor in sulphur available as fuel, by the following method, the object of which is to economize the consumption of coke or other fuel. The matte such as is ordinarily produced is treated with dilute sulphuric acid for the production of sulphuretted hydrogen and this gas is used as fuel in the cupola during a subsequent blast. For instance, when pyritic copper-nickel ore is under treatment the matte produced by the smelting of a first charge is a mixture of the monosulphides of copper, nickel and iron. It is withdrawn from the cupola, pulverized and treated with dilute sulphuric acid in a digester. The sulphuretted hydrogen evolved from the digester is passed into a gass holder, from which it is passed by pipes to a special set of tuyères adjacent to the air tuyères of the cupola. In burning with the air the sulphuretted hydrogen supplies the additional heat necessary for the reduction of further quantities of ore. The intense heat produced in the neighborhood of the tuyères prevents the formation of crusts at that point and enables the whole series of tuyères to be kept continually in blast. The use of sulphuretted hydrogen has the further advantage that the percentage of sulphur dioxide in the flue gases is increased, so that it becomes possible to produce sulphuric acid from such gases when it might otherwise be impracticable. The acid thus produced is utilized for digesting a matte for production of a further quantity of sulphuretted hydrogen. From the residue in the digester the high-grade insoluble copper sulphide containing a small percentage of nickel sulphide is separated and may be shipped to special treatment works or treated upon the spot as may be convenient, while the liquor which may contain a percentage of copper is treated, for instance, by crystallization for the recovery of the iron and nickel sulphates or electrolytically for the recovery of the copper and nickel.

Nickel and Copper.—Concerning the production of nickel and copper from garnierite and magnetic pyrites containing nickel and copper, see the electrolytic process of E. Gunther and R. Franke, described in the Analysis of Current Electrochemical Patents in this issue.

Copper from Roasted Pyrites.—A. Tixier and C. Tortel (875,012, Dec. 31, 1907) propose to extract copper, etc., from iron pyrites, as follows: The iron pyrites are roasted and mixed in a dry state with 2 to 5 per cent. of commercial chloride of lime. The mixed ore is then introduced into vats, where it is sprayed with dilute sulphuric or hydrochloric acid and heated to a temperature of 70 to 80° C. The reaction is allowed to proceed for 12 to 24 hours, whereby copper, lead, zinc, silver, etc., are dissolved. The liquors are drawn off and the residue is washed with lukewarm dilute acid and then with water. The iron residues are practically free from foreign metals.

Zinc.

Continuous Zinc Furnace.—The disadvantages of our methods of zinc smelting are well understood—small units, intermittent operation, large losses of heat and high labor charge. It is very interesting to note how such an experienced zinc metallurgist as Dr. Franz Meyer endeavors to overcome these difficulties (879,482 and 879,483, Feb. 18, assigned to Metallurgical Company of America). His furnace is shown in Fig. 3. The two upper diagrams are vertical cross-sections; the one on the left hand is a section on the line 2-2 of that on the right

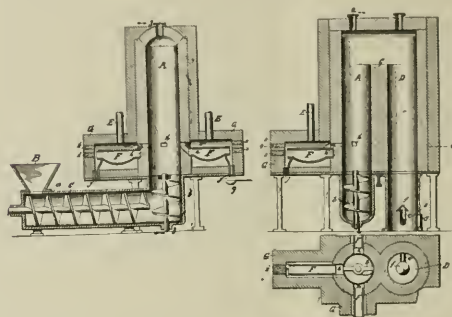


FIG. 3.—ZINC FURNACE.

hand, while the right-hand diagram is a section on the line 3-3 of that on the left hand. The lower diagram on the right is a horizontal section on the line 4-4. Roasted zinc blende or other zinc ore in form of oxide is mixed with coke or anthracite coal in sufficient quantity for reduction of the oxide and for the generation of the required heat. The mixture is fed through the hopper *B* into the conveyor *C*, which feeds it into the bottom of the stack *A*. It is then moved upward by means of the screw conveyor *B* within this stack and in this way the charge is made to rise gradually up to the top of the stack *A*. In rising upward the charge meets the hot products of combustion and of reaction which travel downward in the opposite direction, and the coke and anthracite coal of the charge becomes ignited. As soon as the charge attains the necessary temperature the zinc oxide is reduced and the zinc is vaporized. These vapors are driven down together with the products of combustion and leave the stack through the apertures *h* into the chambers *G* containing the condensers *F*. The zinc condenses within *F* and is periodically withdrawn from *a*, while the uncondensed waste gases occupy the spaces in *G* around *F* and maintain *F* at a temperature sufficient to keep the zinc in molten state. The non-condensed products of reaction finally leave through the exhaust pipes or chimneys *E*. The solid charge in ascending the stack *A* upward is subjected to a steadily increasing temperature, and the maximum temperature is reached at the top *C* so that practically all the zinc is driven out of the ore. The ash of cinder passes over *C* into the ash stack *D*. Here the hot ash gives off its heat to the cold air admitted through the inlet pipes *e*. The movement of the air upward through *D* and downward through *A*

is produced partly by devices forcing the air or gas through the admission pipe *E* and partly by the draft induced by the chimney stacks *E*. The air entering through *e* into *D* while ascending is heated by the ash and at the top *C* meets the carbon of the furnace charge. This is burned to CO_2 , which is reduced by the deep bed of glowing carbon below to carbon monoxide. The carbon monoxide gas escaping through *E* may be utilized for heating or power purposes. To increase the reducing effect, either CO or CO_2 , or both, may be admitted into the charge either at the top of the main stack or through the pipe *s*. Further solid or liquid fuel may be introduced through the inlet pipes *m* at the top. Several modifications of the apparatus are described in patent 879,483.

Zinc-Retort Residues.—Considerable quantities of zinc as well as of fuel are contained in zinc-retort residues. G. Stolzenwald (881,355, March 10, 1908) proposes to utilize them in connection with materials containing zinc, such as have already been used for making zinc-white, in which case the materials have been mixed with fuel and limestone. Stolzenwald mixes the zinc-retort residues with materials containing zinc without any other addition or flux, and heats the mixture in a long bedded continuously acting furnace. A suitable proportion of the mixture would be 100 parts of material containing 10 per cent. zinc with 20 parts of zinc residue containing 2 per cent. zinc and 22 per cent. carbon. During the gradual advance of the substances into the hotter part of the furnace there occurs a reduction of the oxide of zinc with simultaneous develop-

sulphurous gases pass off through the flue 2 to be utilized for manufacture of sulphuric acid. The principal feature of the process is that two different materials are roasted simultaneously, but out of contact with each other in the same furnace, namely, zinc blende (or galena in case of lead), which is fed through hopper 6 and conveyor 10, and iron pyrites, chalcopryite, pyrrhotite, etc., which is fed through hopper 105 and conveyor 7. The object is two-fold, first to roast the ore without any coal, the whole heat being produced from the oxidation of sulphur, and, second, to produce richer sulphurous gases better adapted for the manufacture of sulphuric acid.

Aluminium.

Aluminium-Magnesium Alloys.—Certain aluminium and magnesium alloys have many valuable properties. They are easily cast, are lighter than aluminium and are easily machined. Their melting point is low and it is possible to make castings at a dull red heat. These alloys might supersede pure aluminium for certain purposes were it not for the high cost of magnesium and for the loss of magnesium when the metals are melted together to form the alloy. Concerning a new process of F. von Kügelgen and G. O. Seward for producing these alloys, see abstract in the Analysis of Current Electrochemical Patents in this issue.

Treatment of Fines.

Desulphurization and Sintering of Sulphides.—Sulphide fines have been treated in the past by mixing them with fines, igniting the mixture at the bottom and blowing a blast of air upward through the mixture. This is effective as far as desulphurization is concerned, but only the lower portions are sintered together, while the upper portions, on account of the agitation, remain pulverulent as fines. Arthur S. Dwight and R. L. Lloyd, of Cananea, Mexico (882,517, March 17, 1908), reverse this method by firing the mixture at the top and blowing the air downward through the mixture. The result is that both the desulphurizing and the sintering are complete and uniform throughout the entire charge and practically simultaneous. The method is applicable to galena or iron and copper pyrites. The same inventors (882,518, March 17, 1908) render this process continuous so as to permit a rapid treatment of fines with the production of a relatively thin cake or biscuit of sinter. The ore mass is moved itself bodily relatively to the igniter which is stationary. For this purpose the ore mass is supported on a pervious screen and the screen and the ore mass are together advanced while the mass is ignited at the top at a place between the point of feed and the point of discharge, and an air blast is passed downward through the mass toward the screen.

Converter Process.—Ores and mattes mixed with sulphur, coke and flux have been blown in the past in a converter in order to sinter the mass preparatory to further metallurgical treatment and as a substitute for the more expensive briquetting. J. Savelberg, of Papenburg, Germany (875,852, Jan. 7, 1908), remarks that such a sintering process is applicable to such ores which do not need a special addition of sulphur, as they contain sufficient sulphur to form a matte. This process is also applicable to such ores as iron ores, which for melting do not need sulphur at all. In this case it is sufficient to add to the mixture finely divided coke to furnish the necessary heat. The finely divided ore mixture thus obtained is blown in a Bessemer converter until sintered. This sintered mass is broken up and fed direct to the blast furnace. The fluxes used are acid or basic fluxes, such as quartz rock, limestone, magnesite and the like, a protecting lining in the converter not being necessary for carrying out the process.

Treatment of Smelter Fumes.

In our last issue (page 136) we commented editorially on the problem of fumes from chemical works and smelters. For very good reasons numerous metallurgical engineers are en-

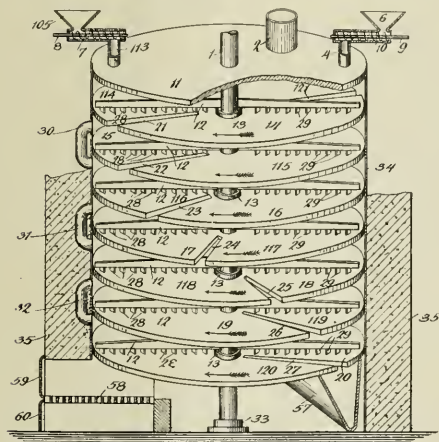


FIG. 4.—ROASTING FURNACE.

ment of zinc fumes, which latter oxidize then again into zinc oxide, when they arrive in the rear part of the furnace. The inventor thinks that if this process is used it does not matter much in zinc smelting practice whether somewhat more or less zinc remains over in the residue, since it can later be recovered from the residue.

Roasting Furnace.—Walter G. Swart (879,842, Feb. 18, and 882,217, March 17, 1908) patents the roasting furnace shown in Fig. 4. A series of hearths are mounted revolvable within the casing 35, each hearth being divided by diametrical slots, such as 21 and 121, into two halves. The non-aligned slots 21, 22, 23, etc., form a plurality of hearths on each level. The hearths rotate in the direction of the arrows. (The grate 58 below the hearths is fired through the doors 59 and 60 and may be used to send the gases of combustion upward through the slots of the hearths and also through the circulating pipes 30, 31, 32, which connect the spaces between successive hearths.) The

gaged at the present in finding a solution of the problems involved, as is indicated by a series of patents recently issued in this field. The object is generally twofold—first, to get rid of those constituents of smelter fumes which are deleterious to animal and vegetable life and which constitute legally a "nuisance," and, second, to recover any metallic values.

Absorption of Fumes in Water.—Most of the inventors treat the fumes with water and their arrangements differ only in the way in which the fumes are commingled with the water. J. T. Yates and J. Devey, of Lehi, Utah, and W. B. Richan and W. A. Devey, of American Fork, Utah (879,023, Feb. 11, 1908), use an apparatus consisting of an elevated scrubber tank, closed at top and bottom, and of an overflow settling tank. The two are connected by a pipe leading from the top of the scrubber to the bottom of the overflow tank. Both tanks are filled with water and the smelter fumes are introduced through a pipe with perforated distributing coil in the form of minute jets into the water in the scrubber tank. They pass upward through a series of screens and are thrashed by revolving beaters in the top of the tank so as to promote their intimate contact with the water and the precipitation of the solid constituents. The gases then pass over to the bottom of the overflow tank and pass through the same in a zigzag course, being again thrashed by means of beaters.

G. Morby, of Robinson, Utah (880,747, March 3, 1908), introduces the fumes at one end of a horizontal inclined flue, water flowing through the flue in the opposite direction. While the fumes pass through the flue they are met by showers of water from above and by air blasts. The air blasts tend to promote a more perfect combustion and the water spray tends to absorb and condense the sulphurous and other gases. The condensation products are taken up and carried off by the water on the bottom.

S. I. Clawson, of Salt Lake City, Utah (880,506, March 3, 1908), uses a revolving wheel in water. The fumes are introduced through a hollow central pipe into the wheel and are discharged through perforations in the periphery of the wheel. Fans are provided at the top to further agitate the water so as to thoroughly mix the fumes with the water.

John R. Moffitt, of Denver, Col. (882,073, March 17), passes the fumes from the chamber where they are volatilized to a hood located at the extremity of the conduit, the hood being immersed in water. The top of the hood is perforated, the walls being formed by punching holes inwardly, producing a jagged inner surface. As the fumes enter the hood they are compelled to travel along this jagged surface whereby they are broken up so as to cause a thorough and even distribution of the volatile products through the liquid, thus resulting in thorough condensation of all condensable elements.

Treatment with Carbon.—G. C. Carson, of Denver, Col. (876,437, January 14, 1908), endeavors to reduce the oxides in the fumes by means of carbon in the apparatus shown in Fig. 5. The fumes enter the chamber through *a* and are forced downward through the column of cold carbon until they enter the incandescent zone at *b*, which has been created by forcing an air blast into kindled carbon through the tuyer *c*. Here the oxides are reduced, like $\text{CO}_2 + \text{C} = 2\text{CO}$, $\text{PbO} + \text{C} = \text{Pb} + \text{CO}$, $\text{ZnO} + \text{C} = \text{Zn} + \text{CO}$. All the elements reduced from the gases which fall into the ash of the consumed carbon are washed through the grate bars with the ash, by giving the water which acts as a seal a jig motion, and are collected at the bottom of the pit beneath the apparatus. Part of the elements will be heated so high as to be in form of vapor and will ascend as such upward into the column on the right where they are cooled and allowed to pass off through the niches into the condensing chamber *x*. The carbon monoxide and nitrogen continue on up through the cold carbon and into the pipe to the gas mains where they are available for heating or lighting. The escaping fumes are quite cold so that there is no loss of heat.

Treatment with Comminuted Slag or Waste Ore.—S. S. Sörensen and G. C. Westby, of Murray, Utah (875,222, December 13, 1907), bring the smokes into direct and intimate contact with finely powdered slag, slag wool, tailings or finely divided waste ore, mixed with water, whereby the sulphur gases in the smoke combine with the bases and metals in these products, forming sulphates, thionous and thionic salts, etc. The metallic values are then precipitated from the solution. If the latter contains gelatinous silica it is necessary to prevent its precipitation if the solution be not sufficiently acid, and sulphuric acid is added to the solution which is then heated and boiled.

The copper, etc., are thrown down as sulphides by the action of the reducing salts present in the liquor. When it is desired to precipitate the last traces of the sulphureted metals, a solution of FeS , FeS_2O_3 and FeSO_4 is added which is obtained by treating metallic iron scrap by a solution of sulphurous acid or crude scrubbing liquors containing free SO_2 .

Where commercial conditions make it desirable, the sulphuric acid liquor used for addition to the solution is made up as follows: A solution of ferric sulphate or an oxidized scrubbing liquor is added to pyrites, then a little sulphurous acid or smoke scrubbing liquor is added to the mixture and the whole is heated, the reaction being $\text{FeS}_2 + 7\text{Fe}_2(\text{SO}_4)_3 + 8\text{H}_2\text{O} = 15\text{FeSO}_4 + 8\text{H}_2\text{SO}_4$. Various modifications of the treatment of the liquor, according to local conditions, are described.

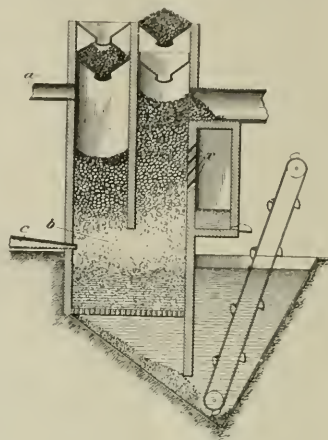


FIG. 5.—TREATMENT OF SMELTER FUMES.

SYNOPSIS OF PERIODICAL LITERATURE.

Electrochemistry.

Production of Earth Alkali Metals.—In *Zeit. f. Elektrochemie*, March 20, F. von Kügelgen gives some notes on his and G. O. Seward's method of producing metallic calcium by electrolysis. This has already been described in our columns (our Vol. V, p. 414). It is emphasized that this method is very essentially different from that of Borchers and Stockem.

Density of Graphite.—H. Le Chatelier and S. Wologdine (*Revue d. Metallurgie*, March) have made a series of determinations of the density of graphite and find that all natural or artificial graphites when completely purified have an identical density of 2.255 at a temperature of 15° C. in relation to water at 4°.

Commercial Silicon.—F. Limmer states in *Chemiker Zeit.*, Jan. 11, that high-grade crystalline and fused silicon is commercially available, but that commercial amorphous silicon is generally very impure and has especially a very high percentage of silica. All the samples of amorphous silicon which he had in his possession contained at least 20 per cent. of silica, one as much as 66 per cent.

Electroanalysis.—In *Zeit. f. Elektrochemie*, Feb. 21, F. Foerster replies to the criticisms of Classen and Fischer (our

March issue, p. 124). The same journal of March 20 contains a reply by A. Classen and a note by F. M. Perkin.

Nickel Analysis.—A. Fischer describes in *Chemiker Zeit.*, Feb. 22, a method for rapid separation of nickel and zinc, which is said to be especially suitable for the analysis of nickel alloys, like nickel coins, etc. The main conditions are: two concentric cylindric screen electrodes; composition of electrolyte 5 grams ammonium sulphate, 1 to 3 grams sodium sulphate, 30 cc ammonia (0.91), 0.15 gram each of nickel and zinc as sulphates, total volume 250 to 300 cc; the cathode potential to be controlled according to the compensation method; potential difference of the mercurous sulphate—2n—electrode against the cathode = 1.355 volts; temperature, 90 to 92° C., time of separation, 20 minutes.

The electrolytic separation of nickel and zinc by the Hollar-Bertiaux method is discussed by F. Foerster and W. Treadwell, Jr., in *Zeit. f. Elektrochemie*, Feb. 21. The separation is satisfactory at or above 90° C. in an ammoniacal solution, if a sulphite is added. However, the determination of the nickel itself is then inaccurate, since the nickel deposit contains sulphur. To avoid this error the nickel is to be redissolved and to be redeposited at ordinary temperature in absence of sulphite; or, for approximate determinations, it may be sufficient to apply a certain percentage correction.

Silver Voltmeter.—In using the silver voltmeter, a platinum crucible is generally used as cathode, but the percentage of accuracy of this arrangement is very low when very minute quantities of silver only (of the order of a milligram) are deposited. E. Bose and F. Conrad (*Zeit. f. Elektrochemie*, Feb. 21) propose to use a very thin platinum wire as cathode and to determine the deposited silver by means of Nerst's microbalance. The authors believe that most irregularities of the silver voltmeter may be explained on the hypothesis of the presence of half valent silver.

Electrode Potentials.—In *Zeit. f. Elektrochemie*, March 6, Wl. Kistiakowsky discusses the methods of measuring electrode potentials against a calomel standard electrode. The primary object of his investigation was to measure the potential of the magnesium electrode. Among the more important precautions which are necessary in such measurements, according to the author are the following: At the point where the metallic electrodes touch the surface of the electrolyte, they must be protected from the action of atmospheric oxygen. Further, the arrangement of the experiment must enable one to rotate the electrode, on account of the necessity of removing local concentration differences. How far this is accomplished can only be determined by comparison of the e.m.f.'s with electrodes at rest and in rotation and after rotation. In many cases it is necessary to eliminate the effect of the varying oxygen concentration in the electrolyte; in general, it seems that the influence of the oxygen on the e.m.f. is the greater the more noble the metal of the electrode. The surface of the electrode must be polished; when dry and wet it must be microscopically examined.

Conductivity and Temperature.—In *Zeit. f. Elektrochemie*, Jan. 31, E. Rasch and F. W. Hinrichsen develop, on the basis of a formula of van't Hoff, the following relation between electric resistivity and temperature: $T \log W = C T + n$, where T the absolute temperature, W the specific resistance and C and n constants. This relation is shown to hold good for dielectric substances (insulators), figures being given for antimony trichloride, glass, china, oils, water and ice (where there is a sudden break in the curve at the melting point), and an arc electrode made from zirconium oxide and yttria.

Ionic Mobility and Its Temperature Coefficient.—In *Zeit. f. Elektrochemie*, Jan. 31, E. Rasch and F. W. Hinrichsen show that for many simple ions in aqueous solution the following relations exist between ionic mobility l and its temperature coefficient a , both at 18° C., $a \log l = \text{const.}$ In *Zeit. f. Elektrochemie*, March 13, F. Kohlrausch remarks that he has proven

before this relation, but that, to be valid in general, another constant must be added. The relation holds good for ions of univalent elements, and may be written in the form $a(C + \log l) = A$, where A and C are constants, or $(a - P)(R + l) = Q$, where P, Q, R are constants.

Iron Salts.—E. Müller and F. Kapeller discuss in *Zeit. f. Elektrochemie*, Feb. 14, the reducing and oxidizing action of iron salts. Ferrous salts are reducing agents, ferric salts oxidizing agents. But their reducing or oxidizing effect is not always the same. Thus it is shown that the reducing action of ferrous salt solutions may be greatly enhanced by fluorine ions.

Anodic Polarization.—In *Zeit. f. Elektrochemie*, March 6, H. W. H. Schellhaass discusses the abnormal anodic polarization due to nitric acid.

Aluminium Carbide.—C. Matignon describes in *Chemiker Zeit.*, Jan. 15, various methods of preparing aluminium carbide C_3Al_4 without the use of an electric furnace.

Chemical Apparatus.

Porous Materials as a Substitute for Cocks in Vacuum Apparatus.

—In vacuum apparatus cocks represent a weak point since there is always a liability of leakage. A. Stock (*Chemiker Zeit.*, Jan. 8) refers to a very simple and practical device which has been proposed by K. Prytz. He suggests to use no cocks at all, but to substitute therefor porous plates which are permeable for air, but not for mercury. The principle is indicated in Fig. 1. A glass tube A, closed at its bottom, has at its top a stopper of porous material. Above the stopper some mercury is placed so that there is no connection between the gas inside the tube and the air outside. If now a second smaller glass tube, B, which is provided at its lower end with an analogous porous stopper, is so inserted into the top of the first tube that the two stoppers make contact with each other, the atmosphere within A and the atmosphere within B communicate with each other through the two stoppers. If B is connected to an air pump it is possible to produce a vacuum in A. By simply removing the tube B the connection of A with the air pump is broken, and there is no possibility of air entering into A.

It is, of course, now possible in the same way to introduce any other gas into A. Prytz used a stopper of firebrick. The present author has found that a mixture of clay with water glass and rubber may be employed for the manufacture of such porous material of great uniformity with respect to the size of the pores. This material is not attacked by dilute acids or by boiling water, and it has the great advantage that without any binding material it can be fused to glass. The porosity is comparatively great. With a difference in pressure of 60 centimeters mercury, 600 to 800 cc gas pass through a plate of 8 mm diameter and 2 or 3 mm thickness per minute. Mercury does not pass through the plate even if the difference of pressure is more than an atmosphere. For short experiments a porous valve may be made in a very simple way by pasting to the flat end of the tube a disc of hardened filter paper.

Sulphuric Acid.

Manufacture of Sulphuric Acid.—G. Oddo in *Chemiker Zeit.*, Feb. 12, refers to the crisis of the sulphur industry in Sicily, and proposes to utilize the Sicilian sulphur deposits for making sulphuric acid. He has made experiments in two Italian sulphuric acid plants, one equipped with Maletta furnaces and lead chambers, the other with Herreshoff furnaces and the contact process. The plant was equipped for the treatment of pyrites and very slight changes were required to use Sicilian ore in the same. He obtained from each ton of ore (31.75 per cent. S) $1\frac{1}{3}$ tons of chamber acid, which is almost the theoretical output (about $1\frac{1}{2}$ tons). In the cham-



FIG. 1.—
POROUS
PLUG FOR
VACUUM
VESSELS.

bers with the Malera furnaces only 1.75 per cent., and in the Herreshoff plant only 0.75 per cent. were lost in form of calcium sulphide or calcium sulphate. Besides the almost complete recovery of all the sulphur, the method has other advantages. The sulphur is completely oxidized on one hearth. The plant may be greatly simplified for the contact process, since (in contradistinction with the use of pyrites) an almost pure and higher concentrated gas is obtained. The acid produced is free from arsenic and other impurities. The residue may be directly used as fertilizer or for making paving stone or for the manufacture of cement. He thinks this method has an industrial future and describes some simple furnaces for practical work.

Iron and Steel.

Silicon as Reducing Agent for Manufacture of Low-Carbon Ferro-Alloys.—In *Stahl und Eisen* of March 11, B. Neumann describes some electric-furnace experiments for making ferro-alloys with silicon as reducing agent in order to reduce the percentage of carbon in the alloy. A furnace of the Heroult type is used with two carbon electrodes suspended in the slag, which is a mixture of 150 to 100 Al_2O_3 and 100 CaO . This mixture is first introduced and fused by turning on the current. The mixture of silicon and the oxide to be reduced is then introduced and the result of the reaction is the reduction of the metal and development of SiO_2 , which is absorbed by the alumina-lime slag. The reduced metal collects on the hearth of the crucible. In the first experiments a chrome-iron ore containing 31 per cent Cr and 13 per cent Fe was reduced by means of silicon in a furnace lined with chromite brick. The silicon used was a commercial high-percentage ferro-silicon containing 91.65 per cent Si and 1.03 per cent C. The result of the process was ferro-chrome containing 38.05 chromium, 3.09 per cent silicon and 1.56 per cent C. The high percentage of carbon is perhaps due to contamination of the metal from the carbon electrodes. The percentage of silicon could have been reduced somewhat by increasing the amount of slag used, but in any case some silicon (about 2 per cent) always passes into the metal or alloy, and this is the weak point of the process. Other experiments were made with chromium, titanium, tungsten and molybdenum. If pure silicon or ferro-silicon low in carbon is used, the alloy or metal produced is also low in carbon, but some silicon always enters into the metal. This is not thought to be disadvantageous for many purposes of the steel industry. The direct reduction of sulphides by means of silicon is stated not to take place according to the simplest formula, while the reduction by means of silicon carbide is said to have no advantage in comparison of reduction by means of carbon in the electric furnace.

Electrometallurgy of Iron and Steel.—A systematic summary of the different electric iron and steel furnaces proposed and in use is given by C. Le Chatelier in *Revue de Metallurgie*, March.

Gold and Silver.

Slimes, Sizing and Classification.—In a paper on the handling of slimes, by Edwin A. Sperry, in *West. Chem. and Met.*, of March, it is pointed out that the success of the final treatment depends very largely on proper sizing, classification and dewatering. Within the past two years, the question of screen-sizing down to even 100 mesh has been so thoroughly met that there need be no hesitation on the part of the designer to adopt one of the several screens made for this purpose. There are two principal types. One is the shaking or impact screen, which has been very successful, though, Mr. Sperry thinks, the necessity of numerous wearing parts militates against it: examples of this type are the Impact, the Centripetal, the Imperial and the Wild screens. The second type is the washing screen, examples being the Callow and the King screens. "either of which has much to recommend it, both in efficiency and life, as well as cheapness of maintenance." It is an unfortunate fact that in ordinary mill practice in the endeavor to properly size the pulp for treatment, the use of the hydraulic classifier is

relied on to an extent beyond its warrant. But while hydraulic classification is theoretically imperfect, yet below a certain point, say, 100 mesh and finer, sizing by screen is certainly impractical, if not impossible, and hydraulic classification must be taken up. As to "cone sizers," two serious disadvantages are pointed out, one being the extra demand on the mill supply of

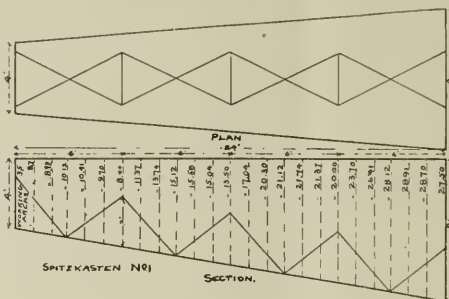


FIG. 2.—SPITZKASTEN.

water, and the other the excessive dilution of the pulp, which offers great difficulties in final treatment. The author considers the spitzkasten to be "one of the greatest assistants which the millman has at his command," and it is a constant source of wonder to him that they are not more universally employed. However, one of the most important fundamental principles is the absolute necessity of a thoroughly placid method of coaxing instead of a violent method of attempting to force the particles to do the will of the operator. In all operations connected with the handling and treatment of slimes the utmost importance must be given to the avoidance of currents or agitation. This applies to all devices, as well as to the so-called improvements to otherwise efficient appliances in which or by which any kind of agitation, constriction of flow, disturbances or currents of

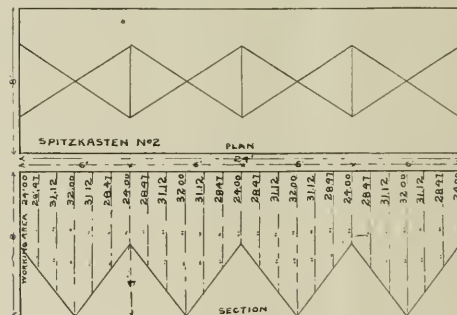


FIG. 3.—SPITZKASTEN.

any kind are created. Among these can be classed the so-called "baffle boards," which are supposed to throw the particles down to the bottom of a settling device of any kind. Also, the form of spitzkasten which, being composed of a series of inverted pyramids, have the overflow from one to the other at or very near the surface. Another is the "over and under" settling tank, containing partial partitions which are passed alternately above and below through constricted sections.

The ideal conditions for the recovery of slime material in proper form and condition for treatment is a gradually decreasing speed of flow for a distance sufficient to give from one to two hours for settlement, and that in a large body of water. These conditions are met in the form of spitzkasten illustrated in Fig. 2. It will be seen that the sectional area is progressively

increasing from the initial to the final end and every chance is given to the "elusive little fellow" to assert his superiority and pass down through the body of water to the point designed for his capture. "The form shown in Fig. 3 is very efficient. In this form it will be seen that the progressive sectional areas are increased and decreased in a series of identical fluctuations at each one of the sections, but there are two causes which would seem to assist in the action of classification and final settlement. One of these is that a portion of the contents is drawn off at each successive spigot and by just so much is the speed of the flow retarded. Another is that in the matter of the finest of the material, the settling action is so slow that it would hardly reach depth enough to be affected by the separating ridges until they reach a considerable distance from the initial or feed end. Above the dividing ridges is what might be called the effective sectional area of the moving body of water. Its sectional area in this case was $3\frac{1}{2}$ ft., or about 80 per cent of the total area figured to the apex. The spaces between the partitions can be said to contain dead water and consequently cannot be figured as effective, but merely acting as a body in which the particles which are carried to it are at rest. In the operation of this spitzkasten it was found that, when running normally, the water at the overflow end was, what might be called, perfectly clear for a depth of about 14 inches from the surface. As the overflow was very shallow and broad, the effect was that of drawing off from the surface without agitation. Compared with the spitzkasten the use of canvas plants gives inferior results. While with the latter the savings of values range from 40 to 50 per cent, the spitzkasten yields 60 to 80 per cent. In the discussion the question was asked whether baffles or burlap or some such coarse fabric would be of value in the spitzkasten. This question was answered in the affirmative, since their tendency is to arrest the slime particles and still cause no deflection or disturbance in the current. While it would not be necessary to clean such baffles very frequently under ordinary conditions, in some cases where the slimes are clayey and have a tendency to pack, they should be cleaned more often.

Copper.

A New Refining Process.—A new process is mentioned in *Metallurgie* of Jan. 8; it is being tried at the Krughütte, near Eisleben, of the Mansfeld Copper Co. The object is to avoid the silver loss during the bessemerizing of copper matte and to avoid also the troubles of the effect of sulphur fumes on vegetation. It has been found that in bessemerizing copper matte the loss of silver increases during the progress of the operation and reaches a maximum after sulphur and iron are removed. Only when a concentration of 79 to 80 per cent of copper has been reached, the loss of silver sets in. It is, therefore, proposed to stop with bessemerizing when the copper matte contains between 72 and 76 per cent of copper. This is then to be treated directly by electrolysis by a process of the Metallurg. Ges. in Frankfurt (German patent 160,046, Oct. 5, 1904). The sulphur is removed by electrolysis and obtained in elemental form. Silver, sulphur, nickel, etc., may be easily, and completely recovered from the anode slimes. The cathode copper is claimed to be as good as any electrolytic copper. The process is being tried practically on a large scale in a plant for a yearly production of 600 tons of electrolytic copper and has been in use since the middle of February, 1907. It is claimed that the process has so far proven to be technically reliable on a large scale, and it is hoped that it will also prove to be a commercial success.

Tin.

Electric Smelting of Tin Ore.—F. Matonet gives in *Metallurgie* of March 22 an account of experiments with smelting of tin ore in the electric furnace. The ore used contained 50 per cent Sn, 7.6 Fe, 3.3 Zn, 1.9 Pb, 0.44 Cu, 7 S, etc. It was found necessary to roast the ore before putting it into the electric furnace. For

the furnace treatment an approximately neutral or slightly basic and alkaline slag is to be used. A resistance furnace must be employed. The chief advantage of electric smelting is to be found in the fact that the slag will absorb much less tin as silicate and will contain no metallic tin occluded in form of globules. The disadvantages of electric smelting are first the loss of tin as vapor and as dust, though this loss may perhaps be reduced when operating on a larger scale. The second disadvantage is the greater impurity of the tin produced. To remove lead from tin, a process similar to the Pattinson process may be employed. The tin product of the electric furnace contains about 2 or 3 per cent of lead. The tin-lead alloy is heated to the melting point (about 230° C.) and then slowly cooled to a temperature a few degrees above the melting point of the eutectics (180° C.). This temperature is maintained for some time. Pure tin crystallizes out while the heavier eutectic mixture of 30 per cent of lead and 70 per cent of tin remains back. This may be repeated several times. By treating a 2 per cent lead alloy in two refining processes, the lead is reduced to 0.2 per cent. The eutectic mixture is then treated by mixing to produce an alloy containing 10 per cent of lead, which is commercially used for cooking utensils.

Aluminium.

The European Aluminium Industry in 1907.—A review is given by J. B. C. Kershaw in the *Lond. Electrician*, March 27. In the early part of the year the demand for aluminium in Europe was in excess of the supply, a result partly due to the very high prices attained by copper and tin. The fall in the value of all metals which occurred during the closing months of 1907 has reacted unfavorably upon the aluminium industry, and the slackened demand with reduction in price of 50 per cent on the 1906 values, has marked the opening of 1908. It is probable that the whole world's output of aluminium in 1907 has approached 20,500 tons, there being 13 producing plants. The following figures from the price lists of the British Aluminium Co., in force at the commencement and end of 1907, show the extent of the fall that has occurred during the year:

	January, 1907.	November.
Ingot metal (pure).....	£200 per ton.	
	1s. 11d. per lb....	£106 per ton.
Sheet metal (per lb.).....	1s. 10d.....	1s. 2½d.
Wire	1s. 11½d.....	1s. 4d.

The Neuhausen Company, which controls the European markets, has also announced a reduction of $33\frac{1}{2}$ per cent upon its previous price, and this company is now offering the metal, for large orders, at a price of 2s. per kilogramme, or 22 cents per pound. On account of the high price of copper, aluminium has been substituted for many smaller parts of electrical apparatus and has proven satisfactory. The British Aluminium Co. are pushing steadily on with the large power development scheme on Loch Leven, and about 2,000 men have been continuously employed there during the greater part of the past year. Two new British companies have been floated. One is the Aluminium Corporation, with a capital of \$2,000,000. It has a water-power plant in course of erection in North Wales, from which 4,400 horse-power will ultimately be obtained, but it has also contracted with two power companies for the supply in bulk of 1,600 horse-power and of 4,000 kilowatts, respectively. The second new British company is the Anglo-Norwegian Aluminium Co., with a capital of \$550,000, which will erect a plant in Norway. New works are also nearly completed at Bussi in Italy, and in Switzerland.

Aluminium as Reducing Agent.—In the March issue of the *Western Chemist and Metallurgist*, W. H. Seamon discusses the use of sheet aluminium for the reduction of iron from the ferric to the ferrous state. In warm and boiling hot solutions containing hydrochloric and sulphuric acids, aluminium evolves hydrogen with great rapidity and reduces ferric salts to a ferrous condition. The author has used aluminium for the reduction of iron in his laboratory with such success that he has

abandoned the use of zinc and stannous chloride entirely. Aluminium is more than three times as active as zinc. The reduction from sulphuric solutions is perfect and more rapid than with zinc. By boiling for four or five minutes, most ores are completely reduced. If greater rapidity than this is desired the addition of a few cc of hydrochloric acid makes the reduction almost instantaneous. As a substitute for stannous chloride in the bichromate method, the use of aluminium is most satisfactory.

Miscellaneous.

Attack of Oxygen on Metals and Alloys.—In the *Chemiker Zeit.*, Jan. 4, E. Jordis reports on experiments of W. Rosenhaupt on the attack of copper, tin and zinc and copper alloys by oxygen. The apparently simple process of oxidation is shown to be quite complicated, especially with respect to the influence of temperature on oxidation. At ordinary temperature none of the metals or alloys is attacked. Copper begins to be oxidized at about 80° C., tin at 100° and zinc at 150°, but with increasing temperature the comparative effect of oxygen on the different metals changes. Certain alloys are less oxidizable than the pure metals. It is interesting to note that the property of zinc of being ductile between 100° and 150° C. does not influence its liability to oxidation.

A New High-Temperature Electric Furnace.

An extended investigation into the suitability of various types of electric furnaces for the production of carbon-free alloys has led to the development of a new furnace well suited to this class of work and for general high-temperature work. The new furnace to be described belongs to the resistance type, but the method of adjusting the resistance of the resistor and, therefore, the temperature, is as simple as it is ingenious.

It has long been known that the resistance of granular carbon can be varied within wide limits, by simply compressing it more or less. In the furnace to be described the same principle is employed, not with granular carbon, however, but with a column of carbon discs which can be screwed together to make more or less intimate contact. (See the patent of Marsh in the *Analysis of Current Electrochemical Patents*, in this issue.) By this construction the furnace attains the advantages of being simple and robust in construction, simple in operation, close in temperature regulation, economical in current consumption and having a resistor that is durable and easy and cheap to replace.

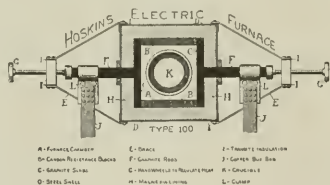


FIG. 1.—DIAGRAM OF ELECTRIC FURNACE.

The construction of a crucible furnace of this type is shown diagrammatically in Fig. 1.

A number of carbon or graphite plates are placed face to face along two sides of the furnace between end plates of graphite and with these end plates, form the walls of the furnace chamber. Graphite rods contacting with the end plates serve to both connect the resistor into circuit and to communicate pressure to the resistor plates applied by means of the screws. The resistor and end pieces are surrounded by a refractory material such as magnesite and contained in an iron casing. The current is carried to the furnace by heavy copper conductors clamped on the graphite rods.

The furnace operates best at from 10 to 50 volts, depending on its size. Where alternating current is available, a special transformer is used to reduce the line voltage to that required by the furnace. An ammeter is connected in the primary circuit as a guide to the control of the furnace. Where alternating current is not available, a rotary converter or a 10-volt plating dynamo or a storage battery may be used as source of current.

The furnace is started with little or no pressure on the resistor plates. On account of the poor contact, the resistance is high and the current small. By increasing the pressure (by simply turning the hand wheel of one of the screws), the current is brought up to the proper value, as indicated by the ammeter. The heat is developed principally at the points of contact of the resistor plates, on account of the high resistance

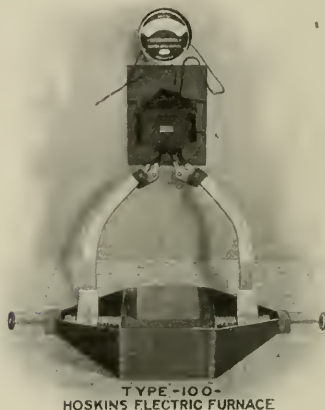


FIG. 2.—OUTSIDE VIEW OF ELECTRIC FURNACE.

at these points. The contact resistance being high compared with the resistance of solid carbon, the cross-section of the resistor can be made large and, therefore, strong and durable. The furnace can be operated efficiently, until the resistor is practically all consumed. The renewal is made by inserting the proper number of plates between the graphite end plates and is the work of a moment.

The number and thickness of the resistor plates depends upon the size of the furnace and the voltage employed.

This furnace can be operated by an unskilled person and is built to withstand hard usage.

The furnace as usually constructed will stand temperatures up to 1800 C., but can be made for a temperature of 2000 C. or above. It can be built as a tube, a muffle or a crucible furnace.

As a crucible furnace it is suitable for melting of platinum, gold, silver, nickel, cobalt, copper, iron, chromium, steel, etc.; for heating the barium chloride used in hardening steels; for determining the melting points of fireclay and similar materials, and for general experimental work with refractory materials.

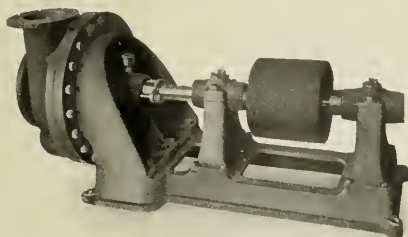
The muffle furnace will not reach the highest temperatures, being limited by the ability of the muffle to stand the heat, but will be found valuable for treating special steels, for assaying and other work requiring a temperature beyond the safe range of wire-wound furnaces.

The tube furnace will be found useful for a variety of experimental work requiring a uniform and high temperature under perfect control.

These furnaces are being placed on the market by the Hoskins Co., of Chicago, and are designated as Type 100.

Improved Rotary Pump.

The adjoining illustration shows an improved rotary pump, recently placed on the market by the Glens Falls Machine Works, of Glens Falls, N. Y. The general form of the blades is of great importance in this type of pump, because the liquid is driven through the fan, partly by the pressure of the blades on the liquid and partly by centrifugal force. The liquid is discharged with but little rotary motion, the resistance to the outward motion of the liquid being so small that the oblique action on the blades is sufficient to effect the discharge without imparting to the liquid the same speed of rotation as is given to the fan. The principal object is to effect the discharge of as large a volume of liquid as possible with the least rotary motion. The great efficiency and ease with which the pump does its work is in the impeller, which is of the enclosed type, having two veins designed on easy and efficient curves to impel the liquid with the least amount of power. There is also a projecting shoulder; either side of the impeller is finished a little larger than the diameter of the intake in the pump so as to get a close contact with a recess on either side of the shell



ROTARY PUMP.

that does not allow the liquid to be churned or re-pumped. The impeller is extra wide and is perfectly balanced against vibration and enthrust. The result is higher efficiency or more work for the same amount of power.

The suction inlet of the pump is of large area, giving a free and easy entrance to the same. It will also be seen that the bearings are long and that the pedestals are widely spaced on either side of the pulley. The pedestals are of oval shape. There are no sharp corners to come in contact with the belt, if it runs off the pulley; the bearings are especially constructed with the view of the oil not getting on the pulley and belt. The packing glands are made of bronze and are extra long, giving ample room for packing and assuring tight packing boxes without excessive pressure and friction on the revolving shaft.

The connecting parts of the pump are machine finished: all joints are planed or turned. They are always in line and require no adjusting. The pump works with an easy rotary motion. The quantity of liquid discharged in a continuous and steady stream is very large in proportion to the power expended; moreover, the pump is simple of construction and of very great durability.

Basket Anodes.

While basket anodes have been used for special purposes in electrolytic work in the past, especially for detinning tin-plate scrap, they are now finding also application in electroplating shops. In this case they are used with the intention to utilize waste metal of any form, such as brass and copper turnings, old anode butts, grain nickel, etc., directly as anode material in the plating tank. Metal in its cheapest form may always, therefore, be used without any waste.

Another advantage is that it is possible to provide easily a very large anode surface; further, that it is easy to regulate the anode surface according to the requirements of the special case or the metal under treatment. The adjoining figures show the basket anode which has been invented by the Ameri-

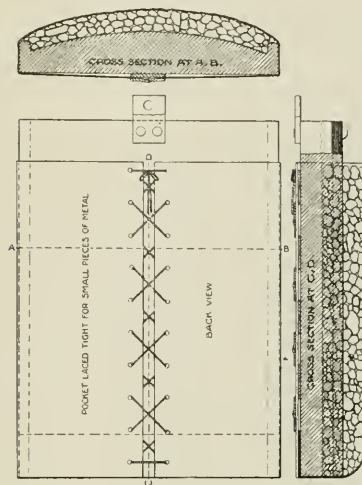


FIG. 1.—LACED BAG FOR SMALL METAL PARTICLES AND CROSS-SECTIONS.

can Nickeloid & Manufacturing Co., of Peru, Ill. They were primarily made for their own use, the company employing now some 1,400 lineal feet of the same and also introducing them elsewhere.

When employed in a vertical position the metal particles must, of course, be enclosed in a bag, and according to the size

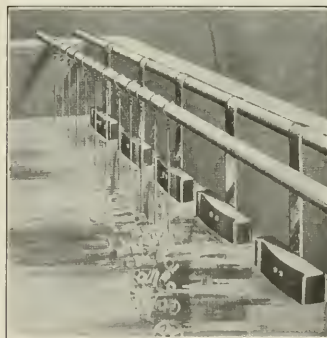


FIG. 2.—BASKET ANODES IN BATH.

of the particles the bag may be laced more or less loosely. Fig. 1 shows a snugly-laced bag for small pieces of metal. The metal may be put in the pocket of the anode with a small shovel, or if this is impracticable the slab is placed in a horizontal position, then the metal is laid on it, the burlap is put in place and laced.

Fig. 2 shows the anodes suspended in the bath.

For cleaning by electricity the anodes are used without the pocket. If the anodes suspended on the sides of the tank do

not provide sufficient surface, additional anodes may be placed in the tank in a horizontal position about three or four inches from the bottom so as to provide room for settlements underneath. No bags are required in this case.

Dry Concentrating Table and a New Electrostatic Separator.

In the paper of Mr. W. G. Swart on ore dressing, published elsewhere in this issue, his very complimentary remarks concerning the dry concentrating table of Messrs. Sutton, Steele & Steele, of Dallas, Tex., are noted. It should, therefore, be of interest to describe here briefly this concentrating table.

The Sutton, Steele & Steele dry concentrating table resembles in appearance the ordinary well-known types of wet concentrating tables, the separation being effected by the reciprocating movement of the table, while air, under slight pressure, is merely used to cushion the ore and give such mobility as to permit of the most exact separations.

The table will treat ore ranging in size from 18-mesh to 173-mesh, and finer. An ordinary suction-blower fan is used. The air enters the table from below the deck and passes through the pervious top, where it instantly expands, causing a film of air, under pressure, on the upper side of the pervious top. This air film supports and stratifies the material under treatment vertically into strata, the heaviest on the bottom, then the next heaviest, etc., and the reciprocating motion of the table causes these strata to travel and separate from each other into zones of separated material. The head motion and table support used impart not only a variable stroke, but also a slight rising and falling motion to the deck, which causes the material to travel rapidly and also takes full advantage of the frictional values of the material being treated, an important factor that does not enter into wet-table concentration.

On account of the protection afforded by the air film, one common domestic cloth will last satisfactorily for over a year on a slime table. No riffles are used on the tables, the deck being perfectly blank. By the peculiar construction of the deck the heaviest mineral being treated is caused to stop at the upper side of the table and immediately travel lengthwise of the deck, while the next heaviest is allowed to pass beyond the heaviest, etc., the lightest, or tails, passing over the mineral before taking up the motion of the table. This causes the material being treated to stratify in bands of separate mineral, which are further cleaned in their travel toward the concentrates end of the table. (This is another application of Mr. Swart's fundamental principle that one should try to coax rather than force the little particles into separation.)

Only a sufficient amount of air is used to float the material. Consequently there is no dust, while the air, being constantly supplied from below, keeps the deck load in a perfectly fluid condition, making separation by the head motion and table adjustments both rapid and thorough.

The size of the deck of the Sutton, Steele & Steele concentrating table is 5 ft. by 12 ft., the weight is 2,500 lb., the capacity from 1,000 lb. an hour of slimes to three tons per hour on 20-mesh. One-quarter to $\frac{1}{2}$ horse-power is required for the tables and from $\frac{1}{2}$ horse-power on slimes to 3 horse-power on 20-mesh material for fans.

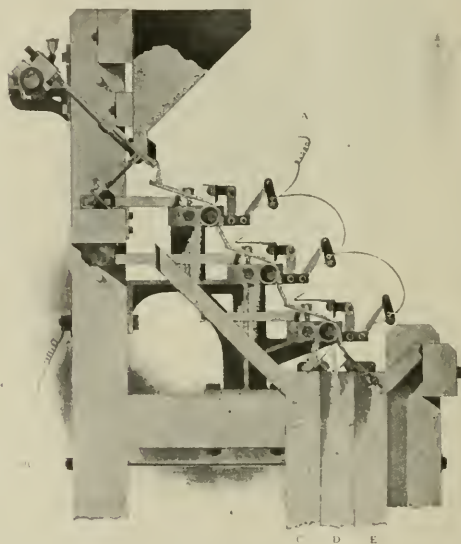
It has long been recognized that to get the best results on any concentrating machine the material to be treated must be first sized, and that the results attained by concentration depends very largely upon efficiency of the sizing end of the plant. For sizing dry material for treatment by the dry-concentrating table, Messrs. Sutton, Steele & Steele have designed a special vibromotor ore sizer. When used in connection with the dry-concentrating table it is usually arranged to deliver 10 products, viz.: On 24, 24 on 30, 30 on 36, 36 on 48, 48 on 68, 68 on 97, 97 on 129, 129 on 140, 140 on 173, and through 173 mesh, and will deliver all of the products in one operation in a perfectly

granular condition, the extreme fines going in the through 173-mesh product.

* * *

In this connection it will be interesting to describe a new electrostatic separator placed on the market by Messrs. Sutton, Steele & Steele. It is shown diagrammatically in the adjoining illustration. The separator consists essentially of a revolving metallic electrode, which is connected to the earth, and to which the commingled mass of particles is fed. Adjacent to this grounded electrode is an opposing electrode consisting of a row of sharp needle points. These points are connected to a high-tension source of electricity, preferably an electrostatic generator. The electricity delivered to the pointed electrode instantly passes off by convection to the grounded electrode, and as the opposite side of the generator from that connected to the pointed electrode is grounded, an electrical circuit is established. The electric charges supplied to the grounded electrode from the pointed electrode are dissipated as fast as received and the mass of commingled particles are thus, by the revolving of the electrode, carried through this convective discharge.

The conducting particles are not affected thereby, as resting on the grounded electrode they part with as much electricity



DIELECTRIC SEPARATOR.

as they receive, and for this reason remain inert; the dielectrics or non-conductors, on the other hand, intercept the charge, are polarized, and adhere to the grounded electrode.

The process consists in applying an alternating or interrupted charge to an electrode to which the commingled mass of particles is delivered, and of regulating the duration of the charges so applied to conform to the dielectric susceptibilities of the different particles. For instance, suppose we have two minerals, A and B; we will suppose that A can receive a charge in one second, while B will receive one in half of a second; it is evident that if the charge be alternated every half second, then A will only be half charged, the continual reversal of the charge keeping A in this condition, or at a constant difference of potential from the electrode. Consequently A adheres to the electrode, while B remains inert.

This is what the makers call "dielectric hysteretic impedance," or the lag of charge, as the residual polarity in the particle modifies the value of the applied charge, causing a lagging of the charge on the particle and consequently the adhering of the particle to the electrode. The name is rather peculiar.

As the principle of this process is based upon the specific inductive capacity of the particles, it is frequently possible to separate minerals both of which may be classed as non-conductors, but which may differ in their specific inductive capacity. Such minerals, for instance, as zinc blende and fluor-spar or barite and zinc blende. The "dielectric separator" was primarily designed for separating iron or copper sulphides from zinc blende, copper sulphides from garnet, zinc from silica, fluor-spar or barytes, garnet from mica, etc., though its field is much wider.

The standard form of the dielectric separator, as shown in the illustration, has three separating electrodes with 6-ft. feed. A is the connection to the source of high potential electricity. B is the ground connection which grounds the entire machine, except the pointed electrodes to which A is connected.

C and E can be either concentrates or tailings, depending on material being treated and the regulation of the charge, as any dielectric can be caused to adhere to the revolving electrode. For instance, when treating iron or copper sulphides and zinc blende to remove the iron or copper, the zinc is stuck to the electrode and passes into hopper C; and when treating zinc blende carrying silica, fluor-spar or barytes, the silica, fluor-spar or barytes adhere to the electrode and pass out into hopper C, while the zinc blende is not affected by the current used and passes into hopper E.

The middling product D, which is usually very small, remains about the same as the crude material, or heads.

The standard size of dielectric separator has a capacity of about 10 tons per day. It treats unroasted raw material, the power requirement being about 3 horse-power for separator and generator. In separating zinc-iron concentrates or middlings, a zinc concentrate carrying less than 1 per cent iron and an iron concentrate carrying from 1 to 2 per cent zinc are obtained.

Notes.

American Electrochemical Society.—At the March meeting of the board of directors the following gentlemen were elected members of the society: Louis E. Ward, Dow Chemical Co., Midland, Mich.; Dr. G. Baborovsky, University of Prague, Bohemia; S. T. Hansen, Jr., Missouri River Power Co., Helena, Mont. At the April meeting of the board the names of the following gentlemen will come up for election to membership: Maurice L. Dolt, Brown University, Providence, R. I.; Thomas A. Mitchell, West Virginia Paper & Pulp Co., Mechanicville, N. Y.; John T. Baker, president J. T. Baker Chemical Co., Phillipsburg, N. J.; William L. Spalding, superintendent Electrolytic Refinery, Buffalo Smelting Works, Buffalo, N. Y.; Paul R. Manahan, Avery Chemical Co., Peabody, Mass.; James M. Breckenridge, student, University of Wisconsin, Madison, Wis.; Oscar R. Foster, De La Vergne Machine Co., New York City; John A. Yunk, General Electric Co., Harrison, N. J.; E. F. Milnerberger, superintendent Canada Zinc Co., Nelson, B. C.; W. C. Slade, Brown University, Providence, R. I.

The C. J. Bogue Electric Company, manufacturers of low-voltage and electroplating generators, engravers' lamps, searchlights and special electrical apparatus, will remove on May 1 from their present factory on Centre St. to more commodious quarters at 513-515 West Twenty-ninth St., New York City.

The Crocker-Wheeler Company is moving at the end of April their New York City offices to 32 Cortlandt Street in the Cortlandt Building, Hudson Terminal. This brings the New York office into close touch with the works and main office at Ampere, N. J.

The Dow Chemical Mfg. Co. of Mansfield, Ohio, have opened a sales office in Chicago, Ill., in the American Trust Building, rooms 644 and 646.

The Polytechnic Institute of Brooklyn have sent us the catalogue of the College of Engineering for 1908-9, with details as to

the courses on chemistry and chemical engineering, civil engineering, electrical engineering, mechanical engineering and a graduate course in science, etc.

The Bausch & Lomb Optical Company of Rochester, N. Y., have issued a very neat pamphlet entitled "A Triangle Alliance in Optics." As is well-known, the company is the outcome of the fusion of three celebrated concerns, the Bausch & Lomb Optical Company, the Carl Zeiss Optical Works, of Jena, and George N. Saegmüller. The booklet should be of great interest to scientists, teachers and all users of optical and scientific instruments generally.

The Denver Fire Clay Company have sent us pamphlets on their Case gasoline furnaces, Case laboratory crushers, Idler's laboratory rolls, and their clay crucibles, scorifiers and annealing cups. They also announce that their glass-blowing department is again in full operation and is prepared to do all sorts of special technical glass blowing and repair work.

The Schutte & Koerting Company, of Philadelphia, have sent us a number of illustrated interesting pamphlets on various products of their works. Among them are Schutte-Koerting rotary lead fans for chemical works, hard bronze valves, Schutte stop, check, stop check and emergency valves, balanced valves, extension rods and stands for balanced valves, balanced trap and trap throttle valves, etc.

Water-Jet Eductors.—The Schutte & Koerting Company, of Philadelphia, have sent us their recent pamphlet on Koerting water-jet eductors. Water-jet eductors are extensively used in connection with city water pressure to drain cellars, pits, cess-pools; in city water-works to wash the filter sand; in power stations and on board ship to discharge the ashes from the boiler room to a convenient location; in mining regions where high-pressure water is at disposal, to sink shafts, to empty places where it is hard to install a pump on account of insufficient space. The actuating fluid can either be taken from a local source, such as water-works, natural water sources in mining regions, water columns, or can be supplied by pressure pumps. The same pamphlet contains illustrations and descriptions of the Koerting water-jet sand-washing plants and of Koerting water-jet ash conveyors.

Welding of Pipes and Rods.—The Goldschmidt Thermit Company have just issued a pamphlet on butt-welding of wrought-iron and steel pipes and rods by the thermit process. The process is of special value for tubes for steam pressure, for deep well lining, for hydraulic work, for compressed air, for ammonia (gas or liquid), for Shelby tubes, and for rods of rectangular or circular section for reinforced concrete.

Wood Preservation.—One of the significant signs of the times is the awakening of the American people to the dangerous destruction of their forest wealth and the necessity of a wise use of what remains of it. Preservative treatment of timber, to lengthen its time of service, is therefore of extreme importance. One of the most effective preservatives is creosote, produced from coal tar, as obtained as a by-product from illuminating gas plants and by-product coke-ovens. Much study is being devoted by the United States Forest Service to creosote oil, to determine what its composition should be to give the best results in preserving timber, under different conditions, and how the most desirable creosotes may be obtained. The reports of these studies, together with detailed description of the more economical processes of applying the preservatives to wood, have been worked into circulars which the government has placed at the disposal of all users of timber and which will be furnished to all who make the request of the Forester at Washington.

The Ames-Alloy High-Pressure Sheet Packing does not melt below 750° Fahr. and has been tested by the Tight Joint Company up to 6000 lb., so that it is suitable for the highest steam pressure and hydraulic work. It is carried in stock by the U. S. Indestructible Gasket Co., of New York City, 1/32 in.

1, 16 in. and 3/32 in. thick and up to 84 in. wide and is made to order from 1/64 in. to 2 in. thick for special uses. The company also furnishes gaskets in any size or shape, according to drawings, for flanges, valves, steam chests, etc., taking the place of wire, corrugated copper or steel gaskets, and particularly the many varieties of rubber and asbestos sheet and leather packings. Ames-alloy high-pressure sheet does not deteriorate, dry out or crack in the boiler room or in service. It is thought to be an ideal substitute for rubber sheet packing anywhere on land or sea, as it is oil, acid, rust and heat-proof.

Perforated Metal (steel, brass, zinc, copper, tin, etc.) is steadily gaining in application as a substitute for wire cloth and other forms of screening. The Allis-Chalmers Co. state that they are now applying it for mining screens of all kinds, in placer grizzlies for hydraulic mining, in screen plates to withstand acidulated mine water, and in separators for coal, ore phosphates and all crushed and ground minerals. The needle-slot screens used for stamp batteries, Huntington, Chilian and other mills are made of this material. For ore-dressing and concentration, perforated metal screens are used in the fixed and shaking screens for jigs, pans, agitators, washers and sizers. The screening apparatus for sluices and waterways is made from this material, and so are baffle and condenser spray plates and pipes. In glucose, sugar, starch and chemical works, perforated metal screens are used for corn shellers, degerminators, attrition mills, separators, etc. Perforated metal has replaced wire cloth for a great many of the purposes for which the latter was formerly used. It is much stronger, more uniform in size of hole or mesh and less liable to tear or rust out. In case of breakage, the damage can be easily repaired without affecting the entire sheet. It is often desirable, also, to arrange screens with certain portions blank. This can easily be done when perforated metals are used, but it is impossible with wire cloth. Unlike the wire fabric, the perforated metal presents a perfectly smooth surface, allowing the material to pass over it smoothly and quickly and it is not liable to become clogged, making it much more satisfactory for sizing, cleaning and separating.

Gas Engines for Steel Foundry.—During January, the Duquesne Steel Foundry, which operates a large plant in the Pittsburgh district, decided to adopt the gas-power system to operate the works formerly driven by steam. The initial equipment will consist of a 400-hp (max.) Westinghouse gas engine of the three-cylinder vertical enclosed type, direct connected to a 240-kw generator, which will serve the various motor drives around the plant. The plant will operate on natural gas, which is available in large quantities in the Pittsburgh district for power as well as lighting at such low rates as to render gas power the cheapest form of power available in this section of the country.

Asbestos Wood is an invention of Prof. Chas. L. Norton, of the Mass. Inst. of Tech., and is mineral in character, being made principally from asbestos fiber, but has the physical characteristics of ordinary wood. It is adaptable to manipulation by means of wood-working tools. As a fireproof substitute for wood, slate, marble and fiber for building, construction and electrical insulation it is now being placed on the market by the W. H. Johns-Manville Co.

Liquid Air.—The March issue of *Compressed Air* contains a detailed description of the new air-liquefying engine at Norwich, Conn., with a reproduction of 12 indicator diagrams. This is the first plant in America for making cheap liquid air, and the first ever successfully put into operation for producing liquid air by the refrigerative effect of expanding air in an air-expansion engine. The cards illustrating the description were taken when the exhaust air from the engine was in form of vapor, at from 220° to 310° below zero Fahrenheit.

"Permanized" Negative Plates for Storage Batteries.—Bulletin No. 9 of the General Storage Battery Company deals with the ingenious and strikingly simple process of Mr. J. Bijur for assuring the maintenance of capacity of negative Plante

plates. Plates treated in Mr. Bijur's method are called "permanized." We described and commented at length on the process in our April issue, 1907, our Vol. V, p. 113 and 143.

Deflocculated Graphite for Lubrication.—The International Acheson Graphite Company, of Niagara Falls, have now placed on the market their graphite, grade 1340, which is a disintegrated, extremely unctuous product of greatest purity for lubricating purposes. Mixed with oil or grease it not only improves their lubricating qualities, but gives them a "body" that prevents the parts from wearing away, as occurs when oil and grease are used alone. Deflocculated graphite is produced by reducing the highly unctuous graphite to the colloidal condition in oil or water. It then remains permanently suspended. One of the useful fields of application for this graphite is mixed with oil that is to be fed through an oil cup. The introduction of a fraction of 1 per cent. greatly reduces the oil consumption. Used in cylinder oil it increases the compression and improves the lubrication. The automobile people are especially delighted by the introduction of Mr. Acheson's "Oildag" (deflocculated Acheson graphite in oil) since it reduces the oil consumption at least 50 per cent. and keeps the engine and valves in perfect condition.

The Bristol Company, Waterbury, Conn., has come under the control of Prof. William H. Bristol, whose inventions this company has been manufacturing since it was first organized in 1889. The business, which has been carried on under the personal name of William H. Bristol, at New York, will hereafter be combined with the Bristol Company, and by this consolidation of interests the Bristol Company will now have the most complete line of recording instruments for pressure, temperature, electrical tests, and for a great variety of other applications. Among them are Bristol's pressure gauges and steel belt lacing, as well as the William H. Bristol electric pyrometers and patented smoked chart recorders, which have been described in detail in our columns. The new pyrometers have come into wide use, there being, for instance, fifty of these pyrometers in service in one of the large steel plants. Another new instrument which will soon be put on the market is the "long-distance electric thermometer," designed especially for indicating and recording refrigeration, atmospheric and drying temperatures. This instrument will fill a long-felt want for use where it is desired to quickly indicate at some central station by means of switches the temperatures at several distant points.

Mr. Edward G. Acheson of Niagara Falls, has received from the American Academy of Arts and Sciences the Rumford Medal for his splendid electric-furnace work which has been "a contribution to the direct progress of man."

Mr. Edward R. Taylor of Penn Yan, N. Y., has received the Elliott Cresson medal from the Franklin Institute in Philadelphia, for his improvements in the manufacture of carbon bisulphide and in the construction and operation of closed continuous-working electric incandescent furnaces.

Matter in the Ionized State.—We have received from Dr. Frank T. F. Stephenson, lecturer on chemistry at the Detroit College of Medicine, a reprint of his paper recently delivered before the Wayne County Medical Society, at Detroit, Mich., on "matter in the ionized state." The author discusses the subject in an interesting way with special reference to physiology and medicine.

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

CALCIUM CARBID (Continued).

681,096, August 20, 1901, Henry Spencer Blackmore, of Mount Vernon, N. Y.

Produces carbid by a reaction within an inert molten bath. Magnesium carbid and calcium fluorid are produced by feeding

magnesium fluorid and calcium carbid into a molten bath of sodium fluorid two parts and potassium fluorid one part. The source of magnesium may be a compound other than the fluorid, reducible by calcium carbid. Inert baths of molten double chlorids or other haloids may be employed. Other carbids than that of calcium may be used as reducing agents.

683,962, October 8, 1901, Hudson Maxim, of New York, N. Y.

Produces calcium carbid from lime and carbon, fed into an electric furnace consisting of a horizontal rotating tube. The current is supplied by rows of electrodes passing through the sides. The tube is a steel shell lined with fire-clay. A tubular molten lining is maintained within the clay lining by centrifugal action. This supplemental lining may consist of "any suitable substance or compound having proper electrical resistance and a specific gravity higher than that of the material to be treated," or it "may be formed or built up from and be constantly renewed by a portion of the materials under treatment, or from one of the products of the reaction effected in the furnace," for example, calcium carbid. This molten layer may act as a resistance conductor, being in contact with the exposed inner ends of the electrodes, entering the sides of the tube. The furnace is cooled by water sprayed on the outside of the tube.

675,646, June 4, 1901, John Zimmerman and Isidore S. Prentner, of Chicago, Ill.

Compresses and feeds a plastic mixture of lime, carbon and a binder, such as borax, graphite and iron, or molasses, upward into an arc sprung between horizontal electrodes. The molten product flows downward into a receptacle beneath the furnace. When one receptacle is filled, it is shifted and another replaces it. The device for compressing and feeding the plastic mixture is a vertical or inclined tube, beneath the electrodes, containing a rotating screw conveyor. The outlet is rectangular and "of substantially the same size as the arc."

676,514, June 18, 1901, Walther Rathenau, of Berlin, Germany.

Produces pure carbid from a charge of lime and coal either of which contains silicon, by adding a metal or its oxid, preferably iron. When the carbon component is anthracite containing 25 per cent. of silica, the charge preferably consists of anthracite, 60 parts; lime, 56 parts, and metallic iron, 28 parts. The resulting silicide of iron contains from 20 to 25 per cent. of silicon.

680,050, Aug. 6, 1901, Claude Marie Joseph Limb, of Lyons, France.

Produces carbids of barium, strontium or calcium, from their sulfids or sulfates. For example, electrically smelts a mixture of barium sulfid, carbon, and a metal or metallic oxid. The product is barium carbid mixed with the corresponding metallic sulfid. Or the charge-mixture may consist of a mixture of barium sulfate, carbon and a metal or metallic oxid. The product is treated with boiling water, to decompose the carbid into caustic baryta and acetylene, this gas being collected, compressed, dissolved in acetone, or chemically utilized. The baryta is crystallized out. The small remnant of sulfid may be separated, before filtering, by adding a metallic oxid or iron sulfate. In smelting, may use either a direct current, producing electrolytic effects, or a simple or polyphase alternating current.

NEW BOOKS.

LEAD REFINING BY ELECTROLYSIS. By Anson G. Betts. 403 pages, illustrated by plates and figures. Bound in cloth. Price, \$4. New York: John Wiley & Sons.

THERMOCHEMISTRY. By Julius Thomsen. Translated from the Danish by Katharine A. Burke. 510 pages, illustrated by tables and diagrams. Bound in cloth. Price, \$2.50. New York: Longmans, Green & Co.

"The author is emeritus professor of chemistry in the University of Copenhagen. The experimental work for this book was carried out in the years of 1851 to 1885, but the greater part belongs to the last twenty years of that period, during which the author was director of the chemical laboratory of the university. His information was published in a four-volume work, "Thermochemische Untersuchungen." He now wishes to make the original results more accessible than in the larger work. He reviews the whole of the numerical and theoretical results without devoting much space to experimental details. He has reduced the work one-fifth and has provided easy access to the results themselves."

THERMODYNAMICS OF TECHNICAL GAS-REACTIONS. By F. Haber. Being seven lectures, translated by Arthur B. Lamb. 375 pages. Bound in cloth. Price, \$3 net. New York: Longmans, Green & Co.

LABORATORY EXERCISES IN PHYSICAL CHEMISTRY. By F. H. Getman. Second edition, revised. 295 pages, illustrated by tables. Bound in cloth. Price, \$2 net. New York: John Wiley & Sons.

THE BLAST FURNACE AND THE MANUFACTURE OF PIG IRON. An elementary treatise for the use of the metallurgical student and the furnaceman. By Rob Forsythe. 368 pages, illustrated by diagrams. Bound in cloth. Price, \$3. New York: David Williams Co.

IRON AND STEEL. By J. H. Stansbie. 388 pages, illustrated. Price, \$2 net. New York: D. Van Nostrand Co.

"This book aims to give as comprehensive a view as its limits will permit of the modern aspects of iron and steel manufacture, together with a sufficient account of its history to enable the reader to follow its march of progress. The main portion has been written from notes used for the courses of lectures and has been brought to date by references to the latest books."

SIMPLE MINE ACCOUNTING. By D. Wallace. 63 pages. Bound in cloth. Price, \$1. New York: Hill Publishing Co.

LIQUID AND GASEOUS FUELS, and the part they play in modern power production. By Vivian B. Lewes. 448 pages, illustrated by diagrams and tables. Bound in cloth. Price, \$2 net. New York: D. Van Nostrand Co.

TOWN GAS AND ITS USE; for the production of light, heat and motive power. By W. H. Y. Webber. 281 pages, illustrated. Bound in cloth. Price, \$2 net. New York: D. Van Nostrand Co.

COAL. By Ja. Tonge. 281 pages, illustrated. Bound in cloth. Price, \$2 net. New York: D. Van Nostrand Co.

INDIA RUBBER AND ITS MANUFACTURE; with chapters on gutta-percha and balata. By Hubert L. Terry. 302 pages, illustrated. Price, \$2 net. New York: D. Van Nostrand Co.

"All information has been brought to latest date. The volume is chiefly designed for the general reader and for the technologist in various branches of industry; it has not gone sufficiently into detail to be a working handbook for the manufacture of india-rubber goods in which various problems still await satisfactory solution."

WOOD. A manual of the natural history and industrial applications of the timbers of commerce. By G. S. Boulger. Second revised and enlarged edition. 367 pages, 91 illustrations. Bound in cloth. Price, \$4.20. New York: Longmans, Green & Co.

HYDRAULICS. By F. C. Lea. For engineering students. 548 pages, illustrated by diagrams. Bound in cloth. Price, \$5 net. New York: Longmans, Green & Co.

THE STEAM TURBINE. By Rob. M. Neilson. Fourth edition, revised and enlarged. 630 pages, illustrated by numerous figures and diagrams. Bound in cloth. Price, \$4.20 net. New York: Longmans, Green & Co.

BOOK REVIEW.

PRACTICAL METHODS FOR THE IRON AND STEEL WORKS CHEMIST. By J. K. Heess, Ph.C. 60 pages. Price, \$1 net. Easton, Pa.: The Chemical Publishing Co.; also New York: McGraw Publishing Co.

This useful little book begins with hints as to location, plan and construction of the iron and steel laboratory. Then follow several pages of general information on experiments, special apparatus, books, standard samples, and standard solutions and reagents.

The bulk of the book is devoted to the sampling and analysis of iron ores, coke and coal, limestone, slag, iron and steel, ferro-manganese, ferro silicon, refractory materials, Portland cement, water for boiler purposes, cylinder oils, gas analysis, bearing metals. The methods are briefly stated and are, in the main, not different from those usually given in similar works on iron analysis.

* * * *

THE COPPER HANDBOOK. A manual of the copper industry of the world. By Horace J. Stevens. Vol. VII: 1907. 1228 pages, bound in cloth, price \$5.00. Houghton, Michigan: Horace J. Stevens.

The endeavor of the author and publisher to improve continually on the general usefulness of this well-known yearly handbook of the copper industry is indicated by the increase in size of the volume. Volume 5 had 882 pages, volume 6 had 1116 pages and the present edition has 1228 pages.

The bulk of the volume is still the statistics of the copper mines and companies of the world with concise descriptive notes. Exceedingly useful information on about 5,000 copper companies is here given. This part of the book is, however, identical with the corresponding part in Vol. VI. The handbook is the result of the work of a single man who collects the data, critically reviews them and writes and publishes the book. It is explained that fire, sickness and loss of five months' time prevented the thorough revision of this part of the book.

However, the introductory explanatory chapters have been revised and greatly enlarged. To the old chapters on history, geology, chemistry and mineralogy of copper and a glossary of mining terms, there have been added new chapters on copper mining, milling and concentrating, hydrometallurgy, pyrometallurgy, electrometallurgy, alloys of copper, brands and grades of copper, and substitutes of copper.

These new chapters are written in plain language so as to be easily understood and are not intended for technical men, but rather for the layman, whether miner or investor. For this reason they should strongly appeal to the general public, as far as it is interested in copper, and should win many new friends for the Copper Handbook.

* * * *

THE ENGINEERING INDEX ANNUAL FOR 1907. Compiled from the Engineering Index, published monthly in the *Engineering Magazine* during 1907. Bound in cloth, 435 pages, price \$2.00. New York: The *Engineering Magazine*.

For a long series of years the *Engineering Magazine* has published every month a classified list of titles of articles appearing in current issues of technical and engineering journals in this country and abroad. The present volume is a reprint of the lists published during 1907.

The list is classified to a certain extent, the main divisions being civil engineering, electrical engineering, industrial economy, marine and naval engineering, mechanical engineering, mining and metallurgy, railway engineering, street and electric railways.

The chapters on industrial economy, marine and naval engineering, street and electric railways are not classified, all items being arranged alphabetically. All other chapters are divided again into subclasses; for instance, mining and metallurgy into coal and coke, copper, gold and silver, iron and steel, mining, miscellany.

* * * *

FIRST PRINCIPLES OF CHEMISTRY. By R. B. Brownlee, W. J. Hancock, R. W. Fuller, M. D. Sohon and J. E. Whitsett. 12 mo, 420 pages, 121 illustrations. Price, \$1.25 net. Boston, Mass.: Allyn & Bacon.

This first presentation of chemistry is an innovation in chemical text-books. It was prepared by five high-school teachers after two years of consultation with each other and polishing up of the material collected. It is the most sane and sensible presentation of the subject which these five experienced teachers

could collectively produce. They cast precedents and traditions aside, and going straight to the root and kernel of the matter, wrote as they would explain, in class, and omitted everything not directly and profitably leading towards their goal. Each criticized and reviewed the work of all the others, with the result that the book is very good. The result is the most lucid, the most translucent, the most careful presentation of the elementary facts and principles of chemistry to be found in English.

The order of development is chronological and rational. Combining weights are explained before atomic weights, as they should be. The atomic hypothesis is most excellently presented, not as a dictum, but as a reasonable explanation of the facts. The phenomena of catalysis, electrolysis, etc., are expressed and explained in absolutely unobjectionable terms, entirely free from hypothesis and the ordinary lingo of the theorist, instilling the jargon of his pet theory into young, receptive minds along with the first elementary facts. Such teaching as we have in this book will make strong, wide-thinking chemists, and not mere parrot-like repeaters of language which they do not and cannot understand.

There are a few slips and a few places where the emphasis might have been changed with advantage. In the difficult matter of explaining Avogadro's hypothesis (p. 74), the weights of equal volumes of elementary gases and their reacting weights are confused. Since all of the students have learned weights and measures primarily in pounds or ounces and feet, it would not confuse them to state that an ounce molecule of any gas has a volume of 22.22 cu. ft. at standard conditions. Such an appeal to the measures they are most familiar with would make the metric measures more real and better understood. In the production of sodium, Castner's name should not be omitted from the description of his apparatus; the reader would think it was Davy's apparatus which was being described. The explanation of hardening and tempering steel is wrong.

The chapter on "Solutions" is far below the level of the other chapters in disingenuousness. It pleads too much the theory of its writer. It is not so fair, so judicial as the others. It seeks to instal the theory rather than to deduce an explanation from the facts. It makes such questionable statements as "Nearly all chemical reactions require the presence of water" and "Non-electrolytes show very little activity." We will not discuss these statements; they are so far from being true that they are poor material to drop into the beginner's mind. This chapter is the poorest in the book, and this just because the theory of its writer is put in the foreground, and facts twisted and manipulated to bolster up the theory. The teacher using the book should carefully lead his students through this pit-fall.

As a general criticism on the whole book, we would say that the quantitative conception of the energy of chemical combination and reaction, as set forth by thermochemistry, is introduced too late and too little into the book. This is the one saving grace which converts chemistry from a qualitative into an exact science, and it ought to be made prominent *ab initio*. One could then explain from the beginning why hydrogen and oxygen explode, why carbon makes a hot fire, why sodium decomposes water, why carbon reduces lithium, and why many other things take place, and where the energy necessary to make them go comes from. These are too valuable assistants to be left out, as they are from most of the book. The combination of Ditté's plan in his well-known French text-book of chemistry, with the lucidity, logic and splendid clearness of this work, would make an ideal work unapproached heretofore in any language.

We hope that many new editions of this book will be required and that the authors will improve it every time in the respects indicated: we will then have an elementary text-book of chemistry which will be an ornament to American scientific literature, a boon to chemical science, and a maker of "manly" chemists.

Electrochemical and Metallurgical Industry

VOL. VI.

NEW YORK, JUNE, 1908.

No. 6.

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the

ELECTROCHEMICAL PUBLISHING COMPANY

239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH. D. *President*
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Yearly subscription price for United States, Mexico and United States dependencies, \$2.00; for all other countries, \$2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, JUNE, 1908.

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Albany Meeting of the American Electrochemical Society.

That the Albany meeting of the American Electrochemical Society would prove highly enjoyable and successful was expected and is only natural. The membership of the society has been drawn together from many different fields, and from the very start the engineers and the scientists, the chemists and the electrical engineers, and the electrochemists proper turned out to be good "mixers," and a strong sentiment of professional solidarity now holds the society firmly together. The good and happy feeling which abounded at the meeting was, however, due, to a large extent, to the exceedingly kind manner in which the local members of Albany, Schenectady and Troy cared for their visitors. The attendance was again large, but it would be much larger, if only those who stay away knew what they are missing in a social way. In view of the exhaustive report of the professional proceedings found elsewhere in this issue, we may simply emphasize here the very wide field of different interesting subjects discussed. The program was again crowded, and the presentation of papers, as well as the discussion, had again to be cut short. It is not clear whether this has become a chronic disease or whether it is getting more acute at every meeting. That everything has been going so well under such circumstances is a credit to the impartiality, energy and tact of the past presidents. For the first time the society has now, as its president, one of the most representative pioneers of our electrochemical industries, Mr. Edward G. Acheson. The outlook for future growth and usefulness is very bright.

The Carbon Cell.

In the Analysis of Current Electrochemical Patents in this issue a patent for a gas cell is abstracted, which has recently been granted to Mr. E. W. Jungner, best known through his activity on the nickel-iron battery on which he has been working independently of, and contemporaneously with, Mr. Edison. Mr. Jungner's gas cell is interesting for the reason that the reaction in it forms one step of a cyclic process, the total result of which is the complete combustion of carbon, as indicated by the equation $C + O_2 = CO_2$. It is another attempt to utilize the energy of this reaction to perform work by a more economical method than in the usual way of changing all the energy of the reaction into heat and converting a small part of this heat (limited by the second principle of thermodynamics) into work by means of boilers and steam engines. In practice we can change the total energy of every spontaneous reaction into heat. In theory it should be possible to carry out such a reaction in a way so as to perform a certain amount of work: if we carry out the reaction at constant temperature and in a reversible way, we get the maximum work that it is possible to get out of the reaction at all at that temperature. This

maximum work is what Helmholtz called the free energy of the reaction at that temperature.

* * *

The reaction of zinc with copper sulphate goes on spontaneously. If we let it go on by simply putting the zinc into copper sulphate, we get the total reaction energy in form of heat. But if we let exactly the same reaction go on in a Daniell cell at constant temperature we change the free energy of the reaction (which in this case is almost exactly equal to the total energy) into electrical energy and we can convert the latter directly into mechanical work; for instance, by driving an electric motor. The more we avoid the production of Joulean heat, by making the internal resistance of our cell infinitely small, and the more we avoid other complicating phenomena like diffusion (or in other words, the nearer we come to ideal reversibility), the nearer we will be in practice to the ideal goal of getting the maximum possible amount of work out of the reaction.

* * *

The first attempts to utilize the combustion energy of carbon more economically, were made in the direction of the construction of a carbon cell, the general design being suggested by the analogy of the Daniell cell as outlined above. It is fair to acknowledge that these attempts were not foolish, but we must frankly state that all these attempts have failed completely. In our usual terminology the chief difficulty may perhaps be briefly summed up in the statement that it seems impossible in practice to get carbon into the ionic state. When the failure had been recognized, the front of the attack was changed in two directions. Not only the methods of trying to find a solution were changed, but also the problem itself was put in a more general way. The combustion of carbon is not the only chemical reaction which would represent an immense progress if it could be carried out as an electrochemical reaction. To mention only two other reactions which would be very useful, we may refer to the oxidation of aluminium and to the oxidation of iron. As to aluminium, if we imagine an aluminium-iron cell, which would electrochemically reproduce the reaction of Dr. Hans Goldschmidt's thermit process (for instance by trying to build a battery on the general scheme of the Edison nickel-iron battery, but with aluminium and iron oxide as active materials at the beginning of the discharge), we have a delightfully interesting battery, light and of a high e.m.f.—on paper. To anybody who knows anything about aluminium, it is unnecessary to point out the difficulties of such an attempt. Others have tried to utilize the oxidation heat of iron and there is more common sense in such attempts than would appear at first glance. Iron can easily be brought into the ionic state in more than one state of valency; and if the chief reaction of the cell would be the oxidation of iron, the reverse reduction in the blast furnace is cheap. True, any iron battery will have a low e.m.f.

* * *

The methods by which inventors now try to solve problems of this kind, have also changed and broadened. The whole desired reaction is often subdivided into two, one of which is carried out as electrochemical reaction, while the other is a purely chemical reaction, offering no special difficulties. Nat-

urally such processes mean necessarily increased complications and Mr. Jungner's patent is a good illustration of this fact. But we cannot deny the possibility that attempts of this general nature may lead to industrial success. Processes of this kind are theoretically possible and are therefore entirely different, for instance, from schemes to invent a perpetuum mobile. The practical net result of the large amount of work which has been done in the past in the field is emphatic recognition of the practical difficulties. Whether anything of industrial value will develop from this work in future can only be answered by continuing to try and work.

The Essential Details.

To the visitor watching the operation of a large blast-furnace, all seems simplicity and regularity. The ore, coke and limestone are hoisted in the big skips and dumped into the voracious maw with machine-like ease. The tapping of the "cinder" and metal is effected with the precision of a military drill. In the meantime, the "pricking" of the tuyeres, the shifting of the gas from one hot-blast stove to another is done with a languid nonchalance by the various workmen, apparently when they happen to feel like it. It would appear that the furnace ran itself. Everything seems a matter of course. In reality, the case is entirely different. The charges have been designed by the use of exact tables, the deductions of thousands of careful experiments, modified by years of practice. The coke, proper to withstand the crushing load of the "burden," has been found after many experiments. The size and shape of the stack, the quality of the refractory brick, in fact, every detail has been decided on after many hard trials. The construction of the heating stoves has had the benefit of the decisions of thousands of minds, tutored and untutored. Sometimes, the untutored mind, or rather the mind tutored by practical familiarity with the art, has through a happy instinct solved by a simple device the problem which baffled the scientific expert. In fact, the essential details of operation have been evolved by the innumerable trials and failures of iron-workers since the days of Catalan forges to the present. The great furnace is an evolution of experience, a survival of the fittest. Behind it lies many generations of the gradual destruction of the unfit. But the visitor cannot see the unsuccessful, any more than we can see in the orderly working of a court of law, the long line of tyranny, rapine and injustice, by the gradual weeding out of which our modern system of jurisprudence has been finally evolved.

* * *

So any new process in metallurgical practice is the result not only of the grouping of a few broad principles, but also of the fitting in of the complex of many little essential details, the result of the winnowing out of the unsuccessful. The process is held together as a practical unity because these details have been worked out by trial on a sound basis and bind together the underlying germinal scientific ideas as cement mortar does the bricks and stones of an edifice. No one has more respect for the fecundity of a scientific idea than this journal. But we know that the successful growth of the two-germ cells depend on the proper environment in which they can draw to themselves thousands of cells of an inferior order and build up an

organic structure. Thus in metallurgical development, the realization of any invention is attained only by the welding of sound theoretical conceptions by numerous little details derived from new practical experience. Lack of comprehension of this necessary complexity has led to undue hope, to undeserved disappointment and to the halting and sometimes the failure of many meritorious inventions. Appreciation of it will make the inventor be sure he is right and then go slow. Some points which are scientifically correct will prove impossible of embodiment. Others with which he expected trouble will solve themselves with ridiculous ease and disappear as difficulties. For he is engaged in the construction of a unity in which the little details are as essential as the underlying germinal principles to which he is attempting to give an embodied life. The conception of an idea may be rapid, its gestation long, and the larger in proportion to its worth.

The Technique of Electrolytic Copper Refining.

The article of Mr. F. D. Easterbrooks in our last issue, on the power plant of the new addition of the Raritan Copper Works, is followed in our present issue by an article of the same author on the new electrolytic refining plant and copper furnaces of these works. These two interesting and able articles give a clear picture of the magnitude and importance of the work involved in the extensions under discussion. It is manifest that a high order of engineering ability and technical knowledge was required in the design and construction of the plant. The investment in a modern copper refinery is large, and the item of depreciation—so fundamentally important in all engineering work—looms high. Particularly in the tank house, since, in view of handling the hot acid solutions, the life of the tanks must be limited and the depreciation charges high, even with the best possible mechanical arrangements. While methods of mechanical handling decrease the labor cost, they increase the depreciation charges. The average life of refining tanks is not known and is estimated differently. We have heard the life estimated as ten years and even six years, though at a visit in 1904 to the pioneer copper refinery of this country, the Balbach works at Newark, N. J., the superintendent of the plant, Mr. F. A. Thum, showed to the writer a series of tanks which had been in operation since the beginning in the early eighties.

* * *

With respect to investment, it is interesting to compare the series system and the multiple system. The investment in the series plant is smaller. First, the investment in power plant is less, because the power required per pound of copper is only about 70 per cent of that in the multiple system, there being practically no contacts or conducting bars and the electrodes being very close together. Further, there is much less copper tied up in the process with the series system than with the multiple system. Finally, with respect to the size of the wire bar furnaces, the fact must be taken into consideration that the cathodes, being much smoother with the series system, can be packed more closely together in the furnace for making wire bars. A certain weight of cathodes, therefore, requires a smaller furnace volume, so that the investment in, and upkeep of, the wire bar furnaces is less per unit weight of copper. These different factors contribute to a smaller investment in the series plant and thereby diminish the fixed charges; and it

is quite probable that these advantages had to be paid for in as much as probably greater difficulties had to be overcome in working out the essential fundamental principles for practice with the series system than with the multiple system. Of course, there is also a reverse side of the picture.

* * *

An important point in favor of the multiple system is that in the case of the series system the anodes, which are thin, even plates, close together, must either be rolled or specially hand-cast. The casting of the anodes with the multiple system is much simpler; mining companies, large producers, can and often do cast their copper directly into anode form and ship them as anodes to the refinery. Further, the series system requires much closer supervision to keep the quality of the cathodes up, resulting again in increase of labor cost. Then, in view of the comparatively high voltage employed, it is not possible to use lead-lined tanks in series plants, which means a considerable increase of cost of tank maintenance over the multiple system. In all these different respects the cost of operation is therefore higher with the series than with the multiple system.

* * *

A word may finally be said as to the current density employed. On account of the necessity of getting smoother cathodes in the series system, no such high current density can be used as in the multiple system. This has an influence on the power required, since, other things being equal, an increase in current density decreases the power per unit of weight, as a direct consequence of Faraday's law. But other things are not equal in a comparison of the series system and the multiple system, and as we saw before, for other reasons the power cost is very essentially lower with the series system than with the multiple system with the same current density. However, the necessity of holding the current density below a certain limit in the series system and the possibility of passing far beyond this limit in the multiple system is a point of greatest importance. It means that the multiple system has possibilities which the series system has not. Not only does the power required per unit of weight of copper go down with an increase of current density, but the whole output of copper is directly proportional to the current density according to Faraday's law. With respect to pushing the output of the works to the limit, the multiple system, therefore, offers possibilities which we have not with the series system. From this point of view, any inherent disadvantages of a high current density will be found rather insignificant, like the effect on silver loss. It is true that the higher the current density, the more active must be the circulation of the electrolyte and the greater will be the danger to stir up the silver mud and loose silver which passes into the cathodes. In this respect the relatively low current density of the series system is a certain advantage. In the whole, it is not easy to balance against each other the relative advantages of the two systems. It is, however, a suggestive fact that both systems are commercially successful on a large scale and have been so for years; it is also significant that the American Smelting & Refining Co. are now operating under the same general manager their multiple-system plant in Maurer and their series system plant in Baltimore, though it is also a fact that by far the largest portion of copper in this country and elsewhere is refined by the multiple system.

Summer Meeting of American Chemical Society.

The 38th general meeting of the American Chemical Society will be held in New Haven, Conn., June 30, July 1 and 2.

The society will, as usual, meet in sections on account of the large number of papers to be presented. The sections will meet in the lecture rooms of the Sheffield Scientific School of Yale University, and will be under the chairmanship of the following members:

Agricultural and food section, A. L. Winton; biological and sanitary section, Thomas B. Osborne; physical section, Frank B. Cameron; organic section, William McPherson; inorganic section, Philip E. Browning; industrial section, William D. Richardson.

Papers intended for these sections must be sent to the chairmen or to Dr. Charles L. Parsons, secretary, New Hampshire College, Durham, N. H., before June 10.

A division of industrial chemists and chemical engineers will be organized at this meeting, and a large attendance is expected.

Programs will be sent all members on June 20. Hotel headquarters will be at the New Haven House.

American Institute of Chemical Engineers.

The committee appointed at Atlantic City last June to consider the formation of an American Institute of Chemical Engineers has found, after obtaining the views of the chemists of this country, that there is a strong sentiment for bringing together into closer relationship those men who more particularly specialize in chemical engineering. A very decisive vote has been received in favor of the formation of the society. It has been decided to call a meeting for the purpose of organization. This will be held in Philadelphia some time during the middle of June. Several men eminent in the profession have consented to address the meeting. Mr. W. M. Booth, Dillage Building, Syracuse, N. Y., is the temporary secretary.

American Foundrymen's Association.

This year's convention will be held in Toronto, Ont., Canada, from June 8 to 10, and a very elaborate program of professional discussions and lectures has been arranged, as well as a fine exhibition. The American Brass Founders' Association, the Associated Foundry Foremen and the Foundry Supply Association will join the American Foundrymen's Association in this convention and a very large attendance is expected.

German Bunsen Society.

The German Bunsen Society will hold its annual convention this year in Austria's capital, Vienna, from May 28 to 31. A special feature of the proceedings will be the presentation of the Bunsen medal.

The program of papers to be read is exceedingly full. Not less than 50 papers have been announced, of which eight (by Profs. Luther, Trautz, Byck, Stobbe, Schumm, Scheffer, von Hubl, Wiesner) will give concise general summaries of various subjects of photochemistry. The whole first morning session will be devoted to this subject. Other papers announced for the second day will be presented by Prof. Loeb on the chemical effects of the silent discharge, by Prof. Le Blanc on the question whether the law of mass action is valid for the silent discharge, by Prof. Kowalski on photoluminescence, by Dr. Weigert on decomposition of ozone by light, and by Prof. Luthers on the energetics of photochemistry.

Among the other papers on interesting scientific subjects we note the following: Prof. Nernst on the theory of electric irritation of nerves; Dr. Trautz on the application of Nernst's thermodynamical theorem to a new problem of equilibrium; Prof. Bodenstein on gas equilibria; Dr. Bechhold on "the measurement of submicrons and amicros by the ultrafiltration method"; Prof. Branner on the rare earth elements in the periodic system; Dr. Paweck on the production of radium from uranium ores, etc.

Of technical and engineering papers we note the following: Dr. Hans Goldschmidt on new thermit reactions; Dr. Herzog on physical and chemical processes in dyeing; Dr. Bechhold on the question whether dyeing is a chemical or a physical process, and Dr. Paweck on metallic electrodeposits as starting material for a new industrial application.

Various visits and inspections will be made and the convention will be closed on Sunday, May 31, by a trip to the Semmering Mountain.

Geheimrat Prof. Dr. Walter Nernst, of Berlin, is the first president of the Bunsen Society. Prof. Wegscheider is the chairman of the local committee in Vienna.

The Iron and Steel Market.

If there has been any change in the demand for finished steel products since last report it has been in the direction of a tapering off in the total. Despite the fact that steel production has been at a rate a trifle less than half the maximum attained last year, the prospects are that the usual summer lull will intervene at an earlier time than usual, thus reducing the production still further.

Pig iron production has undergone a slight diminution from the maximum rate attained this year, which was in March, but is still at the rate of about 14,000,000 tons a year, and this also represents the average rate of production since the beginning of the year. Production last October, the banner month in the industry's history, was at the rate of 28,000,000 tons.

A trifle less than the usual proportion of the pig iron output is going into steel. Early in the year foundry pig iron was accumulating, but it is doubtful if stocks are increasing at the moment, and the maintenance of practically stationary production may indicate a slight gain in consumption by the iron foundries.

WAGES.

The Amalgamated Association of Iron, Steel & Tin Workers held its annual convention in Youngstown, O., in May. It controls the majority of the skilled labor in the iron, sheet and tin plate mills west of the Allegheny Mountains, through scales which run from July 1 to June 30. The scales formulated at this convention, for presentation to the manufacturers, are substantially the same as the existing scales. There will probably be no resistance on the part of the sheet and tin-plate mills, but the iron mills will undoubtedly insist upon a reduction. Iron bars have declined in price, while a determined effort has been made to uphold steel prices. Besides this, it is pretty generally recognized that the large advance made in the iron scale last summer, through a reference of the dispute to a conciliation board, was not altogether just. The Republic Iron & Steel Company this spring abrogated the arrangement for a reference of disputes to conciliation, but the Western Bar Iron Association still has a form of reference. The wage organization is so nearly complete in the Central West that the manufacturers would have relatively little difficulty in paying the wages demanded, were competition among themselves the only matter to be considered, but the enormous growth in basic open-hearth steel manufacture has quite changed the complexion of the scrap market. On most grades of scrap there is competition between the open-hearth steel furnace and the iron mill, and as remelting is fundamentally cheaper than reworking through the iron-mill the competition is severe and the wage matter in the iron-mills very important. The present scale is based on \$5 a ton for puddling, with advances according to the average selling price of bar iron, whereby since March 1 the rate has been \$6.12½. Barring relatively short periods, this is the highest price paid for puddling for more than a quarter of a century.

ORE.

No shipments of Lake Superior ore of any consequence have yet been made. The ore producers recognize that on account

of the large stocks at docks and in furnace yards the present season must, regardless of prices, be a very light one, and as it is desired to introduce the open-shop principle in lake shipping, no serious effort has yet been made to start navigation and it is unlikely that much ore will come down before August 1. Last February it was decided to maintain last season's ore prices through this season, and ore producers have lately reiterated their statements that they intend to do so. Some furnacemen insist, however, that there is a secret understanding that late in the season, when the ore stocks have been worked off, there will be a reduction of 50 cents a ton, making a basis to govern the meager shipments which are expected for this year and furnishing a basis which the ore interests will seek to maintain next season.

PIG IRON.

After the meeting of pig iron and ore interests in New York on May 7 it was formally announced that there were no price agreements on pig iron. This was a fact which the market had been well apprised of for several weeks, as while there was a semblance of an agreement in various districts there was no difficulty in buying iron at a large reduction from the agreed prices. The market has been steadier since this meeting, and enquiry has been larger, while actual sales have shown a slight improvement. In the Central West the market is fairly firm on the following basis, f.o.b. valley furnace: Bessemer, \$16; basic, \$15; malleable, \$15; No. 2 foundry, \$14.50; forge, \$14. Southern iron is fairly firm at \$11.50, Birmingham, for No. 2.

RAILS.

Buying of standard rails continues very light, and specifications on old contracts are coming in rather slowly. The railroads are evidently well satisfied that they can get prompt deliveries any time they want them and are therefore deferring purchases. The Edgar Thomson plant of the Carnegie Steel Company has been in fairly continuous operation, but has been gaited to between 30 and 40 per cent of its normal output. Competition in light rails continues keen between the rerolling mills and the mills making them from new steel, and in a number of cases the latter are meeting the competition of the former, thus doing from \$23 to \$24, while the official price is \$28 on sections 25 and 45 pounds per yard, with extras for lighter sections.

FINISHED MATERIALS.

Demand for wire products has tapered off slightly, after a period in which the wire mills ran to about 75 per cent their normal capacity. In tin plates operations are slightly heavier, as the leading industry has started an additional plant and is now running 213 tin mills, this giving it substantially as large an output as it has ever had. The independents are also running practically full. The mills state that on account of the backwardness of the buying season it will be necessary to maintain substantially the present rate of production through July and August. The steel car plants are doing practically nothing, and demand for car and ship plates is at the lowest possible ebb. Merchant steel bar production is also light, and may not be over 25 or 30 per cent of the normal, while the iron bar mills are slightly exceeding this percentage. Rail production is about 40 per cent of normal.

Billets remain at \$28, Pittsburg, with half the freight added for delivery at points taking from \$1 to \$3 freight from Pittsburg. Sheet bars remain at \$29.50, delivered Pittsburg and nearby points, and at \$29, Pittsburg, plus half the freight, for most other points. Finished steel products remain on the following basis, Pittsburg:

Beams and channels, 15-inch and under, \$1.70.

Plates, tank quality, \$1.60 to \$1.70.

Steel bars, \$1.60, half extras.

Wire nails, \$2.05, base.

Sheets, 28 gauge, \$2.50.

Tin plates, 100-pound cokes, \$3.70.

CORRESPONDENCE.

Mathematics of the Induction Furnace.

To the Editor of *Electrochemical and Metallurgical Industry*:

SIR:—With respect to the critical remarks which have been made on my mathematical theory of the induction furnace (American Electrochemical Society paper, New York meeting, 1907), I may refer to them more in detail in later publications. However, I may state here that practical experience shows a satisfactory agreement with my equations, especially as far as the value of the power factor is concerned. As to the stray flux, I think that my calculations are perhaps still insufficient. But in any case the formulas are a valuable aid for a more extended investigation and a good guide in practical research, having served me to design the furnaces to be installed at the Krupp works in Essen. I trust that their operation in practice will closely agree with the theoretical predetermination.

PARIS, FRANCE.

GUSTAVE GIN.

Commercial Electric Steel and Gas Power.

To the Editor of *Electrochemical and Metallurgical Industry*:

SIR:—Since there exists a manifest desire on part of many steel makers to know, not only what the electric furnace can do in steel manufacture, but what it is actually doing in commercial operation, the annexed table should be of interest.

It is a sheet from the works laboratory, giving the composition of steel made in September, 1907, in regular commercial operation in successive heats at La Praz, France, in the Héroult electric furnace, from cheapest scrap and ore.

The raw material used averages high in phosphorus and sulphur and consists of the cheapest kind of steel and castings scrap obtainable in the local market. As will be noticed from the laboratory sheets, the product made is high-grade tool steel, used by the best works in France and elsewhere.

Nearly a dozen steel plants of good standing are now running the Héroult electric process on a commercially successful basis and their capacity is being constantly increased.

What we principally claim is that we can use the cheapest raw material, making the steel makers practically independent of raw material, no matter where they are located, to produce in the Héroult furnace, as an adjunct to oxidizing furnaces, like basic-open hearth, a purer, better and more uniform material than can be made by any other process.

The additional cost over common open-hearth and Bessemer steel is small, and depends naturally on the cost of power and on the extent to which it may be desirable to purify and refine the product.

Our steel is an absolutely homogeneous product, of a finer grain and tougher, in combination with a greater degree of hardness, owing to its purity and the refining operations it has passed through. As compared with the old crucible process, still employed by most makers of high-grade steel, Héroult electric steel is superior, more uniform and can be produced at much lower cost, while the difference between the electric process and the open-hearth or any other oxidizing furnaces is evident from the essential conditions under which they are operated.

In the Héroult furnace, the oxide of iron is reduced by carbon and the product of reaction, being oxide of carbon, escapes, while in the open hearth, the oxide of silicon and manganese, as a result of the operation, remains mostly in the metal, producing irregularity and weakening the steel.

I have already pointed out in previous articles in this journal the absolute control of carbon by recarburizing in the Héroult furnace and the great advantages of this process in making alloy steels, both in regard to economy and thorough amalgamation and uniform distribution of the alloying elements in the metal bath.

Aside from the general demand by railroads and other large

I. A. PRAZ WORKS, SEPTEMBER, 1907.

No. of	Heat	S.	Pb.	Mn.	C.	Si.
1726.....	0.005	0.014	0.247	1.130	0.227	
1727.....	0.005	0.013	0.304	0.910	0.196	
1728.....	0.005	0.012	0.273	0.970	0.266	
1729.....	0.008	0.010	0.312	0.815	0.241	
1730.....	0.009	0.008	0.377	1.183	*0.108.	
1731.....	0.006	0.010	0.338	0.891	0.184	
1732.....	0.004	0.011	0.286	0.856	0.166	
1733.....	0.007	0.012	0.338	0.900	0.186	
1734.....	0.010	0.011	0.312	0.786	0.217	
1735.....	0.006	0.009	0.273	0.846	0.174	
1736.....	0.004	0.012	0.299	0.885	0.174	
1737.....	0.011	0.011	0.195	0.790	0.141	
1738.....	0.007	0.008	0.247	0.932	0.163	
1739.....	0.005	0.011	0.299	0.843	0.152	
1740.....	0.009	0.011	0.234	0.797	0.164	
1741.....	0.014	0.010	0.312	0.810	0.111	
1742.....	0.007	0.011	0.221	0.929	0.130	
1743.....	0.010	0.011	0.195	0.840	0.151	
1744.....	0.012	0.011	0.473	0.757	0.185	
1745.....	0.002	0.012	0.182	0.958	0.165	
1746.....	0.010	0.009	0.260	0.769	0.165	
1747.....	0.009	0.010	0.208	0.802	0.141	
1748.....	0.013	0.011	0.208	0.874	0.117	
1749.....	0.007	0.012	0.208	0.860	0.152	
1750.....	0.009	0.008	0.273	1.030	0.211	
1751.....	0.011	0.008	0.195	0.850	0.223	
1752.....	0.006	0.006	0.260	0.850	0.223	
1753.....	0.012	0.005	0.221	0.803	0.221	
1754.....	0.006	0.006	0.221	0.760	0.191	
1755.....	0.007	0.011	0.286	0.888	0.134	
1756.....	0.008	0.013	0.208	0.820	0.155	
1757.....	0.000	0.011	0.325	0.882	0.258	
1758.....	0.006	0.008	0.231	0.890	0.178	
1759.....	0.004	0.011	0.338	0.803	0.204	
1760.....	0.008	0.008	0.234	0.757	0.125	
1761.....	0.004	0.008	0.221	1.275	0.138	
1762.....	0.004	0.010	0.286	1.250	0.317	
1763.....	0.007	0.009	0.338	1.095	0.213	
1764.....	0.003	0.008	0.208	1.218	0.176	
1765.....	0.004	0.012	0.247	1.291	0.199	
1766.....	0.005	0.011	0.247	1.181	0.137	
1767.....	0.004	0.012	0.234	1.196	0.221	
1768.....	0.005	0.008	0.208	1.215	0.124	
1769.....	0.006	0.009	0.182	1.209	0.190	
1770.....	0.006	0.011	0.208	1.161	0.152	
1771.....	0.008	0.011	0.260	1.284	0.121	
1772.....	0.005	0.010	0.221	1.208	0.156	
1773.....	0.006	0.008	0.260	1.210	0.199	
1774.....	0.005	0.004	0.208	1.211	0.217	
1775.....	0.006	0.004	0.208	1.198	0.181	
1776.....	0.004	0.011	0.286	1.192	0.253	
1777.....	0.005	0.010	0.247	1.168	0.146	
1778.....	0.005	0.007	0.195	1.195	0.207	
1779.....	0.006	0.007	0.247	1.183	0.174	
1780.....	0.007	0.008	0.221	1.062	0.150	
1781.....	0.003	0.008	0.247	1.125	0.186	
1782.....	0.004	0.006	0.200	1.122	0.156	
1783.....	0.008	0.012	0.260	1.266	0.205	
1784.....	0.005	0.007	0.195	1.228	0.205	
1785.....	0.004	0.007	0.260	1.145	0.197	
1786.....	0.009	0.007	0.286	1.130	0.230	
1787.....	0.007	0.007	0.260	1.150	0.184	
1788.....	0.008	0.007	0.247	1.150	0.246	
1789.....	0.005	0.011	0.273	1.110	0.190	
1790.....	0.006	0.005	0.260	1.183	0.176	

* Charge 1730 is high-speed tool steel and contains 4.83 per cent chrome and 20.79 per cent tungsten.

consumers of staple products of steel, for a better and more uniform quality, I have also come across many manufacturers requiring a large tonnage of steel forgings and steel castings, who are unanimous in their demands for a supply of a better and more uniform product.

It is a well-known fact that the steel casting industry has made no progress of late years. I am told, on good authority, that there is a wastage of about 50 per cent in medium and light-weight castings, particularly in castings of odd shapes. This is principally due to impurities and sluggishness of the metal in casting.

With less than one-third of the power necessary for purification and refining, the liquid metal can be held indefinitely in the Heroult electric furnace, without any loss in its composition, and a highly liquid metal, can be cast uniformly, free from impurities and gases.

It is my belief that the enormous waste now suffered in steel foundries above mentioned, could be practically overcome, and that castings of greater strength and better and more uniform quality, could be produced.

In addition to this, a large tonnage of forgings could be substituted by castings, which would give additional work to steel foundries and save a lot of work and expense to manufacturers, who are obliged to use forgings on account of the difficulty to obtain satisfactory steel castings.

Notwithstanding the fact that steel forging and steel casting makers are obliged to scrap a large percentage of their product before shipping same, in trying to meet the requirements of purchasers, the latter are subject to a great loss in rejecting forgings and castings, due to serious defects discovered in the process of finishing the same.

There is undoubtedly a large market for a better quality of these products, and for a sounder and more homogeneous article. To produce these by the old, reliable crucible process is prohibitory on account of excessive cost. Aside from this it is not convenient and practical to produce anything but light-weight forgings and castings by this process.

The Heroult process overcomes all these obstacles and eliminates every objection. With comparatively little additional cost the hot metal may be taken from the Bessemer or open-hearth furnace and be thoroughly purified and refined in our electric furnace.

The whole situation centers in the cost of electric power. Now, the modern large gas engine operated with waste gases from blast furnaces or with producer gas from cheap fuel has made it possible to generate electric power at a very much reduced cost compared with steam power. Yet the great majority of our industrial plants, steel works included, which have been otherwise progressive, are still continuing to obtain their power by means of obsolete steam engines.

They will soon be forced, for economical reasons, to keep pace with progressive Germany, where steam power has been replaced by gas engines of large, small and medium units to an enormous extent. A few very large and progressive steel plants in this country are proceeding in this direction and show the others the way they will have to follow.

Figures don't lie. The intelligent steel maker, if he takes the trouble to do so, can readily convince himself that electric power can be generated by modern gas engines at a surprisingly low figure as compared with former cost.

The power being the principal item, or practically the only one in the cost of electric steel making and refining, it will be a question of a comparatively short time after introduction of gas power when all Bessemer converters and open-hearth steel furnaces and even cupolas will be provided with electric furnaces as auxiliaries.

The progressive makers that will bring then a superior product on the market first will force the rest to follow suit. The twentieth century has begun with a new chapter in the steel industry, and its head-line is electricity.

NEW YORK CITY.

R. H. WOLFF.

Albany Meeting of the American Electrochemical Society

The thirteenth general meeting of the American Electrochemical Society, held at Albany, Schenectady and Troy, on Thursday, Friday and Saturday, April 30, May 1 and 2, was very successful. There was a satisfactory attendance throughout the meeting, and all the members of the local committee did their utmost to make the visitors feel at home.

The meeting was exceedingly enjoyable in all its features, though it was a slightly strenuous affair with three sessions devoted to the reading and discussion of papers on Thursday (even without the extra sessions of Section Q), with morning sessions on Friday and Saturday, and with the fulness of the program with respect to visits and excursions.

The annual business meeting, held at the beginning of the afternoon session of Thursday, showed the society to be in a satisfactory condition.

The number of members is now 715, and there is a fairly steady increase of about 10 per cent. in the membership per year.

The election of officers for the coming year was announced as follows: Mr. E. G. Acheson, of Niagara Falls, is the new president, while Dr. J. W. Richards and Mr. P. G. Salom were re-elected as secretary and treasurer, respectively. Dr. C. A. Doremus, Mr. C. P. Townsend and Dr. W. R. Whitney were elected vice-presidents for two years, in addition to three vice-presidents whose term did not expire. Mr. F. A. J. Fitzgerald, Mr. Alois von Isakovich and Prof. S. A. Tucker were elected managers for three years, in addition to six other managers whose terms did not expire.

The Pacific Coast Borax Company offers a prize of \$500 for a process of making ferroboration from commercial borate of lime, the prize to be awarded by the board of directors of the society.

Dr. A. T. Lincoln, of the University of Illinois, suggested the creation of associate membership for students. The proposal was referred to the board of directors.

The three sessions of Thursday were held in the ballroom of the Hotel Ten Eyck, in Albany; the session of Friday morning in Union University, Schenectady, and the session of Saturday morning in the Rensselaer Polytechnic Institute in Troy.

After the Friday morning session, lunch was tendered to the society by the General Electric Company, followed by an inspection of the works, which took up the whole afternoon.

The importance of these world-renowned works is so generally recognized that nothing need be said here in this respect. Some very large transformers in course of construction and the beautiful immense Curtis steam turbine hall attracted well-deserved attention and admiration.

To the chemical engineers in the party many of the apparatus and processes in use by the General Electric Company in various departments were of special interest, like the drying and impregnating apparatus in the wire and cable department, the lead-covering machines, the gas annealing furnaces and forges of the Rockwell Engineering Company; further in the insulation department ball mills of the Abbe Engineering Company, pug mills, mixing machinery for preparing the clay, molding machinery, etc. For the heat treatment of insulators gas furnaces are employed for the lower temperatures, while an interesting electric furnace with automatic feeding and discharging

arrangement is used for the higher temperatures. The gradual development of mica insulation plates from crude mica is quite interesting.

The electric furnace house contains experimental furnaces of fair size of all the familiar commercial types.

In the evening of Friday an informal dinner united the whole party in the Ten Eyck in Albany.

After the Saturday morning session lunch was taken at the Rensselaer Inn in Troy, while the afternoon was devoted to various excursions and visits. Among the places visited were the Watervliet Arsenal, the Earl & Wilson linen factories, the Burden Iron Works, and W. & L. E. Garley's factory of engineering and surveyors' instruments, transits, levels, physical apparatus, thermometers, etc.



EDWARD G. ACHESON, PRESIDENT
OF AMERICAN ELECTRO-
CHEMICAL SOCIETY.



FIG. 1.—EXTERIOR OF HARGREAVES-BIRD CELL.

Quite a large party made an excursion to the Duncan paper mill of the West Virginia Pulp & Paper Company, at Mechanicville, N. Y., with its new electrolytic chlorine plant as chief attraction.

The well-known Hargreaves-Bird diaphragm cell is there in use, and the well-arranged and well-managed installation was generally admired. Water power is utilized to generate the current for the electrolytic works, there being two 300-kw, 126-volt, 3095-ampere Westinghouse generators, running at 150 r.p.m. There is spare room for four more generators.

In case of lack of water or of an accident, power can be had from the main steam-turbine-driven power plant of the works, where 2000 kw in alternating current and 800 kw in direct current are available. To produce the current for electrolysis, a motor-generator is provided, consisting of a 450-hp, 500 volt, 750-ampere motor and a 300-kw, 100-volt, 3000-ampere generator, running at 450 r.p.m.

Figs. 1, 2 and 3 show some details of the electrolytic chlorine plant. The cell room contains a series of rows of cells, each two rows being connected in series. Since each row contains 14 cells, 28 cells are connected in series across the 126-volt

main. One corner of the very clean cell room is illustrated in Fig. 1, which shows clearly the exterior of the Hargreaves-Bird cell.

Fig. 2 shows the absorption towers in the background and the settling tanks for the bleaching liquor in the front. Fig. 3 shows the construction of the anodes.

The inspection of these works, through which the visitors were led with great courtesy by officers of the company, was greatly enjoyed.

In connection with the professional sessions devoted to the reading and discussion of papers, several interesting exhibits had been arranged. Mr. Max Meyer, of the New York

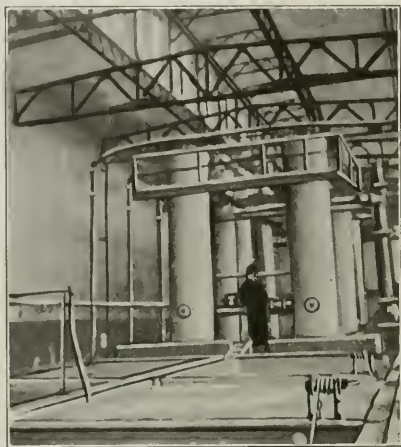


FIG. 2.—ABSORPTION TOWERS AND SETTLING TANKS.

branch of Voigtländer & Sohn, exhibited several of their well-known microscopes, while Mr. Foster, of the Taylor Instrument Company, of Rochester, exhibited several types of pyrometers of the well-known construction of the Cambridge Scientific Instrument Company, which will hereafter be made by the Taylor Instrument Company in this country.

In the following we give a complete account of all the papers presented at this meeting.

* * *

Resistances of the Order of One Hundred Thousand Megohms.

The first paper was presented by Dr. HOWARD L. BRONSON, of McGill University, Montreal, on the construction and accurate measurement of resistances of the order of 100,000 megohms. An instantaneous measurement of very small currents is of great importance for researches on the passage of electricity through gases and on radioactivity. The best method is probably the "constant deflection method" of Rutherford, but it requires the use of permanent high resistances of the order of 10^9 ohms.

While it is possible to get resistances as large as 10^9 ohms by means of fine carbon lines on ebonite or ground glass, or by means of amyl alcohol or xylol in long capillary tubes, such resistors always show considerable variation and uncertainty. The carbon line seems to have practically its entire resistance at one point and to be merely a case of bad contact, which is bound to be very uncertain and subject to all kinds of external conditions. The liquid resistances have very large temperature coefficients, and seem to be subject to a variable polarization. In both classes of resistances, there is necessarily present a considerable amount of insulating or dielectric mate-

rial. The absorption due to this is a function both of the time and temperature.

These difficulties were overcome by making use of the resistance of an ionic gas on the basis of the law that the ionization current, through a gas subject to a constant source of ionization, is approximately proportional to the potential difference between the plates when this potential is small.

The author constructed resistor vessels of ebonite of inside dimensions of 2.5 by 1.5 cm, with electrodes of aluminium, the active material consisting of about a tenth of a milligram of radium bromide. It is generally possible to so adjust the distance between the plates that a linear relation will exist for a considerable range of potential. Nevertheless, it is necessary to get a calibration curve for every such vessel, and it is recommended to use a double method of calibration.

The results given in this paper would suggest the possibility of making of standard vessels of this type and preserving them as permanent high-resistor standards. They would have a much higher resistance than any of the usual standards and ought to remain constant over a long period. They would be found very useful for insulation testing or any very high resistance measurements.

In the discussion which followed and in which Messrs. Bancroft, Hering and Wolff participated, it was suggested by Mr. Hering that the Brownian movements of colloidal particles might be made use of for measuring very small currents, since the application of the smallest electric field causes the particles to move in a certain direction. In reply to a question of Dr. Bancroft, Dr. Bronson stated that the gas in the vessel does not appear to affect the results.

* * *

Absorption of Radioactive Emanations.

A paper on this subject was presented by Dr. R. W. BOYLE, of McGill University. Dewar has studied in detail the absorption of ordinary gases by charcoal and has found absorption to occur to a very considerable degree at low temperatures. In order to find how far the similarity goes between radioactive emanations and ordinary gases it was of interest to study the observation of radioactive emanations by charcoal with varying temperature.

Different kinds of charcoal were tested and it was found that coconut charcoal is the most suitable for absorption tests. The absorption was determined as a function of the temperature, most experiments being made with thorium emanation. The absorption was determined between the temperature of solid dioxide and about 210° C., which is the approximate temperature at which charcoal begins to oxidize. The analogy between radioactive emanations and ordinary gases with respect to absorption by coconut charcoal appears to be complete. As a matter of fact, in everything else except in decay, radioactive emanations behave just like ordinary gases.

* * *

Temperature Coefficient of Weston Cell.

Dr. FRANK A. WOLFF, of the Bureau of Standards, gave a preliminary report on some measurements of the temperature coefficient of the e.m.f. of the Weston cell between 0 and 40° deg. C. Measurements were made for every five degrees, and in each case a complete cycle was carried out, passing, for

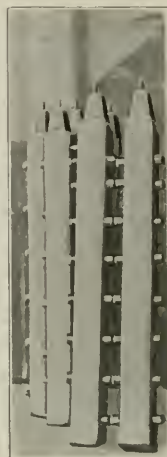


FIG. 3.—ANODES.

instance, from 5 deg. C. down to 0 deg., maintaining the cell at this temperature for about two days and then returning to 5 deg. One of the important results of these tests is that some cells exhibited very considerable hysteresis, especially those with abnormal initial values and also cells which were normal initially, but subsequently developed irregularities.

Dr. Wolff gave the following new approximate formula for the change of the e.m.f. ϵ of the Weston cell at the temperature t degrees C. in volts with varying temperature:

$$\epsilon = \epsilon_{20} - 0.000040 (t-20) - 0.000009 (t-20)^2 + 0.0000009 (t-20)^3$$

It was found necessary to use a third term in this equation, while the usual (Reichsanstalt) formula contains only two terms. According to the above formula the e.m.f. has a maximum within the region between 0 and 5 deg. C., while there is no such maximum according to the Reichsanstalt formula. It is interesting to note that the maximum solubility of cadmium sulphate lies within the same region of temperature and that

Mercury Cathodes in Nitric Acid.

A paper by Mr. J. W. WILKINSON, of Cornell University, on this subject, was presented in abstract by Prof. W. D. Bancroft.

Tafel has given some years ago an example which appeared to show a distinct difference between chemical and electrochemical action. When copper dissolves chemically in nitric acid, the latter is reduced to NO. On the other hand if nitric acid is electrolyzed with a copper cathode, ammonia is set free at the cathode. Similarly we obtain hydroxylamine by electrochemical reduction of nitric acid at a mercury cathode and again NO by chemical reduction with mercury. Thus chemically we get NO both with copper and mercury, electrochemically we get other reduction products and different from each other.

J. W. Turrentine has already dealt with the case of the copper cathode (*Transact. Am. Electrochem. Soc.* Vol. X, p. 49) and shown that if the chemical and electrochemical reactions are carried out under exactly the same conditions, the



PHOTOGRAPH TAKEN AT SCHENECTADY.

the portable cells of the Weston type are saturated at the same temperature.

The paper was discussed by Messrs. Carhart, Hering and Lidbury. In reply to a question by Professor Carhart, Dr. Wolff stated that in the temperature cycle to which the cells were subjected, those which showed hysteresis showed greater deviations from the normal values in the falling branch of the temperature cycle than in the rising branch.

Dr. Carhart expressed the opinion that hysteresis is due to the size of the cadmium sulphate particles and to delay of diffusion. According to Dr. Carhart, mercurous sulphate when chemically precipitated gives better results than when electrolytically prepared. On the other hand, Dr. Wolff stated that the size of the grains of the cadmium sulphate appears not to have any effect, and that the cause of hysteresis must be found in the paste limb. Further, according to Dr. Wolff, it does not matter whether the mercurous sulphate is electrolytically or chemically prepared; no real difference was found when the mercurous sulphate was made by six or seven different methods.

products are the same. The chief point is whether there is copper present as ion in solution. If so, the chief product of electrolysis is N O, just as in chemical reduction. The present paper by Wilkinson deals with the case of the mercury cathode in exactly the same way and shows that the conditions are here exactly analogous. If we have mercury in solution we get the same products chemically and electrochemically. This is another proof of the general rule of Dr. Bancroft that chemical and electrochemical reactions yield exactly the same products, if only both reactions are carried out under exactly the same conditions. The paper was briefly discussed by Dr. Patten.

* * *

Joseph Henry in Albany.

Mr. JAMES F. McELROY gave an account of the early work of Joseph Henry in Albany. Contrary to published statements, the birthday of Joseph Henry was Dec. 17, 1797. In 1826 he became instructor in mathematics in the Boys' Academy, the building still being located within the Academy Park, near the

Albany Capitol. On April 6, 1829, he described before the Albany Academy the construction of his new electromagnet which was immensely more powerful than any electromagnets formerly designed. Formerly bare wire was used for the windings and, of course, only one single layer could be used. Henry employed cotton covered wire ("cotton insulation, well waxed") and was thus enabled to use several layers of wire. Henry also clearly understood and explained the difference between series and parallel connection of cells.

In the Boys' Academy in Albany Henry installed the first electric signal transmission system over a wire of more than a thousand feet long. This was called by Mr. McElroy the first electromagnetic telegraph ever constructed.

In the spring of 1831 Henry discovered that a galvanometer, which he had in series with the electromagnet winding, showed a momentary deflection when the armature was suddenly pulled away from the electromagnet. This was before Faraday's fundamental discovery of electromagnetic induction in the autumn of the same year. Henry left Albany in 1832 to become professor at Princeton and later director of the Smithsonian Institute in Washington.

In the discussion which followed, Prof. Carhart referred to the signal transmission system installed by Henry. He emphasized that this was not only the first electromagnetic telegraph, but should rather be considered as the first electric power transmission on record. Henry clearly understood the importance of high voltage for power transmission as is shown by his emphasizing the advantages of connecting the cells in series. When the name Henry was selected for the unit of inductance at the International Electrical Congress in Chicago, 1893, Mascart, a Frenchman, proposed the name of Henry; it was seconded by an English delegate. Two definitions of the unit Henry were proposed by a committee appointed for this purpose, but neither definition was found satisfactory. Then Ferraris, the distinguished Italian physicist, although not able to speak English fluently, proposed, within two minutes, the definition which found general approval and which was definitely adopted.

* * *

Fundamental Units of Electricity.

The society has received a request from Director Stratton, of the Bureau of Standards, to appoint a committee on units and standards which should co-operate with corresponding committees of the American Institute of Electrical Engineers and of the American Physical Society. It is the purpose of the Bureau of Standards to have American opinion crystallized in regard to the questions to be taken up by the next International Congress on electrical units. The committee appointed by the society in compliance with this request consists of Mr. Carl Hering, chairman; Dr. Theodore W. Richards, of Harvard; Dr. H. T. Barnes, of McGill, and Dr. Edward Weston.

In connection with these proceedings, a paper was presented by Dr. FRANK A. WOLFF, of the Bureau of Standards, in which the present situation of international fundamental units of electricity was concisely reviewed.

An informal international conference, called by the German Reichsanstalt, was held in October, 1905, and decided on three things: first, that there should be only two fundamental units; second, that the international ohm and the international ampere should be these two units; third, that the international volt should be defined by the ohm and the ampere. The conference rejected the recommendations of the Bureau of Standards and of Prof. Carhart, who advocated the adoption of the standard cell instead of the coulometer for the definition of the second fundamental unit. As to the necessity of having only two fundamental units, there was and is general agreement.

But the above action of the conference can only be considered as preliminary, since the conference had not yet seen fit to draw up the necessary specifications, as was pointed out by Dr. Wolff. It will be the duty of the next international congress to adopt

definitely the two fundamental units and to formulate the specifications and agree upon the values to be used in the definitions.

Since all agree that the ohm should be one fundamental unit, the chief question is, whether the ampere or the volt should be the second fundamental unit. Three points are to be taken into consideration.

First, accuracy of reproduction. (a) As to the fundamental principle involved, the definition of the ampere is based on Faraday's law. But, while this law may be considered as absolutely true, the weight of the silver deposit may not agree exactly with the law on account of secondary reactions. On the other hand, the definition of the volt is based on an equally fundamental principle, though it has no generally accepted name; this principle states that the decrease of energy of a reversible galvanic battery in watt-hours equals the coulombs given out by the battery, multiplied by $e - T \frac{de}{dT}$, where e is the

e.m.f. in volts and T the absolute temperature (Gibbs-Helmholtz equation). With respect to the fundamental character of the principle on which the units ampere and volt are based, there is no preference of one unit over the other. (b) As to the purity of the materials to be employed in the reproduction of the units, this point may be neglected, since the materials can be supplied by the national bureaus or laboratories. (c) As to the number of measurements required, the coulometer is at a great disadvantage compared with the standard cell. The cell automatically takes up its value.

Concreteness is the *second* point to be considered. There is no such thing in a silver coulometer. When a measurement has been made, there is nothing left but a silver deposit which is of no use for further measurements. The cell, on the other hand, is always ready for further measurements.

Ease of reproducibility is the *third* important factor and here the standard cell is again at a great advantage.

If the attribute of constancy of the standard cell would be established, then taking this together with its reproducibility, the volt seems even better than the ohm as to suitability for a fundamental unit.

While the German law legalizes the ohm and the ampere, yet the Germans have used a particular value for the e.m.f. of the standard cell since 1898, and the result is equivalent to legalizing that value in the first place.

While the accuracy of reproduction by different investigators has been satisfactorily established in the case of the cell, this has not been done in the case of the coulometer, for which only relative accuracy of reproducibility has been determined.

Although in the light of the present evidence, the adoption of the standard cell may be favored, yet the Bureau of Standards, in Washington, advocates a systematic international co-operation looking toward establishing the accuracy of reproduction of both the cell and the coulometer.

* * *

Corrosion of Iron.

The retiring president, Prof. CHARLES F. BURGESS, of the University of Wisconsin, then presented his presidential address dealing with "the corrosion of iron from the electrochemical standpoint." The design of iron and steel structures has reached a high degree of development, but we know very little concerning the life of completed steel structures, we have no exact figures on their rate of decay and on their depreciation. This may vary much with local conditions. It may be as low as 1 per cent and as high as 20 per cent per year.

The corrosion of iron has been studied as an electrochemical phenomenon by Whitney and recently in greater detail by Walker and Cushman (our Vol. V, pp. 254, 257, 270, 343, 363). Iron corrodes when anode. All agree on this, but it seems wrong to assume that iron cannot corrode when made cathode. Prof. Burgess said that laboratory experiments had shown that under certain conditions iron may corrode when it is the

cathode. A possible explanation of this peculiar fact may be that under certain conditions a surface film may be present on the iron which protects the iron. When it is then made cathode, the surface film breaks down and the iron surface is laid bare and rendered liable to corrosion. This tentative explanation is analogous to the breaking down of the protective oxide film on an aluminium surface when used as cathode.

Electrolytic corrosion may be due to currents from an external source. The most important case of practice is the corrosion of underground water and gas pipes by the stray currents of electric railways, using the rails for the return circuit. The return current does not remain in the rails, but enters into the earth, and where it finds an iron or steel pipe it will enter the same. Whenever the stray current then leaves the iron into the surrounding ground, the iron is the anode and will be corroded. Methods have been found to mitigate this trouble, but it has not been completely solved. In theoretical respect many things are still unknown. For instance, we do not know whether Faraday's law holds strictly good for the earth or, in other words, whether the earth is a perfect electrolyte or whether the earth perhaps does act like a metallic conductor for small currents.

It is, however, not necessary that current from an external source be present to produce electrolytic corrosion of iron. Iron in contact with other metals (like copper) and moisture forms a galvanic couple itself, and an electric current will result, passing from the iron to the moisture and from there into the other metal and then back to the iron, thus flowing in a circle as required, without any external source of current. The more electronegative the other material, the more pronounced is the phenomenon. Carbon in contact with iron and sulphur in contact with iron represent such galvanic couples.

An observation of the effect of deflocculated graphite on the prevention of corrosion is apparently abnormal. Iron was rubbed in with Acheson deflocculated graphite and exposed to the atmosphere, together with other samples of iron. The iron treated with graphite did not corrode, while the other samples did. But when a heavy rainstorm came and washed the graphite off, the iron corroded just like the other samples. The action of the graphite is not yet fully understood; it may perhaps act simply like a paint.

From the above principle it follows that free carbon or sulphur particles in the surface of iron will cause galvanic couples and produce corrosion. Non-uniformity of the composition of the surface is, therefore, of greatest importance, since it represents a tendency for beginning corrosion.

Several microphotographs of the surfaces of iron were shown, for instance of electrolytic iron and of pure Swedish iron. "Slag areas" in the latter may represent the first cause of corrosion, resulting in localized pitting. Prof. Burgess emphasized repeatedly that the microscope will be found a very useful instrument in studying the corrosion of surfaces.

A large part of Prof. Burgess' address dealt with the influence of mechanical strain on the corrosion of iron. This problem has been suggested by the old question what becomes of the energy stored in a wound-up spring, when it is subjected to corrosion. It seems possible that the energy stored in the spring might manifest itself in form of an e.m.f., or in general that mechanical strains might have an effect on the e.m.f. of electrochemical corrosion. Various investigations have been made by Hambuechen, T. W. Richards, Walker and others, with greatly different results. Prof. Burgess reviewed the whole subject and thought there were sources of error in all. Prof. Burgess then gave an account of some experiments made by himself, the results of which were shown in very interesting lantern slides.

In one set of tests, steel bars were subjected to tension up to a point just before rupture. The tension was then released and the surfaces of the bars were ground down to a uniform

diameter and polished. When subjected to corrosion it was found that those portions of the test bars which had been strained were corroded to a much greater degree than the rest. This effect was very clearly shown and unmistakable in the lantern slides. The corrosion tests were made either by simple chemical corrosion without current in a hydrochloric acid solution or with current in a neutral solution, using the test bar as anode.

In a similar way torsion strains were applied to the middle portions of test bars. After the strain had been released the test bars were subjected to pure chemical corrosion. The electrochemical nature of the corrosion (although no external current was employed in these tests) became manifest, from the fact that the upper and lower parts of the test bars (which had not been strained) became densely covered with gas bubbles, while the strained central part remained bright, there being sharp lines of demarcation between the parts where gas bubbles appeared and where not. The explanation is that the gas bubbles appear at the cathodes, while the part free from gas bubbles acts as anode and it is this part which corrodes. These lantern slides proved manifestly the greater tendency of strained iron to go into solution.

The punching of boiler plates is also interesting in this respect. The usual specification is that boiler plates should be drilled. Punching weakens the metal, sets up strains in it and subjects it to greater subsequent corrosion. This was also shown by lantern slides of a corroded punched piece of boiler plate, showing the greatest corrosion close to the hole, where the strain had been a maximum, and deep grooved lines running off from the hole into the surrounding metal. These rays of lines indicate strain lines and indicate weakness of the iron in these directions.

Strains produced in tempering steel also show up clearly in corrosion tests.

The final part of Prof. Burgess' address dealt with the effect of temperature differences on corrosion, with special reference to locomotive boiler tubes. It was shown that the pitting and grooving observed in practice is what should be expected theoretically. The effect of steam pressure was also investigated. An interesting result found was that air dissolved in the water appears to be detrimental. It seems that the oxygen of the air acts as depolarizer at the cathode in agreement with Dr. Walker's theory. On the other hand, the presence of carbon dioxide in boiler water is not a disadvantage.

The interesting address of Prof. Burgess elicited quite an extended discussion. Mr. E. G. Acheson spoke on the production of steel by means of deflocculated graphite. A piece of bright steel immersed in water containing deflocculated graphite does not rust, while it rusts in other ordinary water. But immersing a piece of steel once or repeatedly in water containing deflocculated graphite does not produce a permanent cure against corrosion. Nevertheless, for the protection of special pieces of machinery, experience seems to show that rubbing graphite into the surface is valuable.

Other speakers participating in the discussion were Messrs. McElroy, Wolff, Lidbury, Sharp, Grower, Hering and Bancroft. The latter emphasized that not only the e.m.f. of galvanic couples set up at the surfaces of iron and steel structures should be considered, but also the possibility of surface films. The latter may stop the current, due to its insulating properties. The existence of an e.m.f. due to a galvanic couple indicates only the first initial tendency of the surface to corrosion.

Prof. Carhart referred to two suits now pending as to the liabilities of tramway companies for alleged damage done to water and gas pipes by stray currents. It is by no means easy to trace in a special case the vertical poles or columns are also subject to corrosion. The thermoelectric effect should not be overlooked in such investigations. A communicated discussion by Dr. T. W. Richards pointed out that electrodes which are not in equilibrium do not give constant results.

Corrosion of Rochester Steel Conduit.

Mr. R. H. GAINES presented a paper on this subject giving details of a concrete instance of rather disastrous corrosion. The Rochester steel conduit was laid in 1893 or 1894. The part which developed corrosion later on was coated with asphalt. There developed in the whole 164 rust leaks.

Soon after the first leaks developed, the conduit was examined and wherever there was an indication of something wrong an anti-corrosive paint was applied. It was thought that had not this been done far more leaks would have developed.

Mr. Gaines examined the conduit in June, 1907, in behalf of the New York Water Supply, which plans a large aqueduct for which steel pipes may be used. The inspection of the conduit in 1907 showed that about four-fifths of it was still in good condition, while in one-fifth corrosion was active, partly in its first stages, but partly had progressed further.

The pits which had developed were mostly round, although some were longitudinal. When the rust was taken out a round hole was found. The thickness of the pipe is 5/16 in. Many of the holes look just like pin holes.

Almost the complete corrosion appeared to be from the outside, while the pipe was hardly corroded from the inside. It seems that continuous contact with water is not nearly as detrimental as intermittent supply and withdrawal of the water; of course, the salts outside in the soil had also great effect. It was first suspected that electric stray currents from outside sources were at the bottom of the trouble, but it was not possible to detect any.

Mr. Gaines concludes that no single cause can be offered as a satisfactory explanation. This case of corrosion seems to be the result of a combination of physical conditions. First, there was an inadequate protection of the pipe. Secondly, the influence of the soil containing chlorides of magnesium, calcium, etc. (nearly one per cent soluble salts), with an excess of water, is undoubtedly of great importance. Thirdly, we have the lack of homogeneity in the structure and composition of steel as a determining factor. The development of galvanic couples results in what Mr. Gaines calls "auto-electrolysis." Stray currents from an outside source may aggravate the trouble, but are not needed to produce electrolytic corrosion.

This paper also elicited a long discussion. Mr. Hering said that the fact that the milliammeter does not show a current is no proof that there are no stray currents. Mr. McElroy related a case in which stray currents had passed through a pipe whether it was perpendicular or parallel to the street railway line. Dr. Bancroft remarked that chlorides in contact with iron will, of course, cause rust, but the important thing in which iron and steel engineers should interest themselves is to find out exactly the lack of homogeneity in the structure and composition of commercial steel. Dr. Sharp referred to the self-deception of alleged experts in the use of the voltmeter in so-called "electrolytic surveys." Serious as the situation of destruction of water pipes by stray currents is, some tests made by "experts" are ridiculous: they read an indication of the voltmeter, assume so and so many ohms in the earth and conclude that there is a current flowing of so many hundred thousand amperes. Dr. Potter emphasized that the electrolyte should be eliminated by using an impervious non-conducting coating on all underground pipes. Mr. Gaines gave in his reply a number of analyses made in his investigation.

* * *

Industrial Applications of Aluminium.

Mr. E. BLOUGH, of the Aluminum Company of America, presented a paper dealing purely with the commercial aspects of aluminium. An interesting exhibit shown by him was a sample of aluminium made by Mr. Charles M. Hall in 1886 with current from a galvanic battery.

In its early history the aluminium industry was hampered

by the extravagant untrue claims of the general press. But the industry long ago reached a sound condition by pushing the use of aluminium only for those purposes for which it is specially well adapted. Aluminium is applied either alloyed or pure. Alloys are chiefly used for castings. Practically all aluminium castings are made from alloys and are used for many purposes. Among the great number mentioned by the author there were electric meter frames, meter covers, pipe fittings for aluminium tubing, etc.

Aluminium has now become quite an important element in steel manufacture, being used as a deoxidizing agent to produce sound castings. While only very little is used in each case many thousands of pounds per year are employed for this purpose.

Aluminium sheet metal may be had hard or soft. It is rolled in all gauges from the very thickest to the very thinnest. It is used for automobile bodies, for signs, for cooking utensils, etc. In the New York Subway some of the cars are lined with aluminium. In a large number of Eastman kodaks it is also employed.

Aluminium tubes are made in all sizes and shapes. The thinnest pipes are used as indicating instruments for needles.

Aluminium is finding now a steadily increasing market in the chemical industries, as in acetic acid plants, for nitric acid condensers, ammonia concentrators, further in pulp mills, etc.

Copper pipe is now made lined with aluminium for use in surface steel condensers.

Aluminium rods are made in all shapes for various uses. In electric power stations aluminium busbars are employed, while for high-tension transmission lines the use of aluminium wire is steadily increasing in importance, especially in the West. Street and interurban railway companies also use it. "Bi-metallic wire" is now being introduced for various purposes, being a steel wire coated with aluminium.

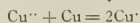
An interesting exhibit showed the development of an aluminium coffee pot in the various steps of manufacture from the plain aluminium sheet which is brought into the proper form by drawing and spinning. The Japanese army was fully equipped during the last war with aluminium mess kettles, which proved very satisfactory.

* * *

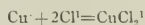
Copper Anodes in Chloride Solutions.

Mr. SAML DUSHMAN presented an account of a very elaborate experimental investigation. When copper is used as anode in hydrochloric acid it passes into solution both as cuprous and cupric salt, and according to the variation of the conditions of the experiment (variation of the current density, concentration, etc.) either the cupric or the cuprous salt will prevail.

Mr. Dushman explained that at the surface of the anode there is a chemical equilibrium between the cupric and cuprous ions and the metallic copper in contact with the electrolyte. There are two equilibria, indicated by the equations:



and in presence of chlorine



The determination of the equilibrium constants of these two reversible reactions form the first part of the investigation.

The second part of the investigation relates to the experimental determination of the change of concentration at the electrode by means of a very elaborate special arrangement. It was thus found possible to calculate the concentration exactly at the anode.

* * *

Electrochemistry of Light.

The session of Monday evening was chiefly taken up by an experimental lecture of Prof. WILDER D. BANCROFT, of Cornell

University, on the electrochemistry of light, proposing an electrolytic theory of photochemical phenomena.

While in some cases the effect of light on chemical processes is due to a simple heating effect of the light, this explanation does not cover those processes properly called photochemical. In the latter light energy is transformed directly into chemical energy. Grothuss, in 1818, formulated the first two laws of photochemistry. The first law, which appears to be universally accepted, is that only light of those wave lengths which are absorbed by the chemical system can (not necessarily will) produce a photochemical effect. The second law is that the action of light can be considered as analogous to a "linear voltaic cell." While this is not very clear, the following quotations from Grothuss will indicate his meaning.

"Light separates the constituents of many ponderable compounds and forces them to form new compounds with its own imponderable elements $+E$ and $-E$, just as the portions of the voltaic battery do to a still greater extent." (In our present terminology we would probably express the same idea by saying that light ionizes the compounds into ions carrying opposite electric charges.) According to Grothuss, "a ray of light is a line along which the elements of neutral electricity arrange themselves into polar fashion." (This suggests at once the familiar mental picture of the Grothuss ionic chain extending from anode to cathode in an electrolytic cell.) Grothuss suggests, therefore, that there is a general analogy or parallelism between photochemical and electrochemical phenomena. The object of Dr. Bancroft's paper is to emphasize the very great value of this fundamental conception, namely, that the chemical action of light is essentially electrolytic in nature.

Dr. Bancroft gave an immense amount of special facts illustrating Grothuss' principle. But in this abstract it is possible to refer to a few typical examples only. (A very full account of the subject covered in the first part of Dr. Bancroft's lecture may be found in a paper of Dr. Bancroft in the April issue of the *Journal of Physical Chemistry*.)

Practically all the salts of silver are decomposed by light under some circumstances, the final product being either silver or some other reduction product. The decomposition products are the same as those obtained by electrolysis. Ferric chloride, sulphate, oxalate, tartrate, citrate and sulphocyanate are decomposed by light under suitable circumstances with formation of the ferrous salt, just as would happen if the solution were electrolyzed. The double ferric oxalates and the ferricyanides are reduced by light and by electrolysis. In presence of a suitable oxidizing agent such as oxygen, ferrous sulphate or sulphocyanate is oxidized to the ferric salt. It is a matter of common knowledge that ferrous salts can be oxidized electrolytically.

The example of the action of light on ferrous sulphocyanate is of historical interest since it was studied by Grothuss with remarkable experimental skill. In experiments on the behavior of ferric sulphocyanate dissolved in alcohol, Grothuss found "that when air was kept away from the solution, sunlight caused the red color to disappear. If the solution were placed in an unstoppered flask and exposed to the light, it was decolorized in the morning, reddened at noon, and decolorized again in the afternoon. Grothuss set himself to the task of accounting for this difference in the action of the sun's rays at different hours of the day.

He soon established that difference in the heat of the sunlight at morning or at noon had nothing to do with the reaction, but that the whole phenomenon was due to the fact that in the morning and evening hours the rays of light are nearly parallel to the surface of the liquid and therefore pass directly into the solution from a non-oxidizing medium, the glass walls of the flask in which the tincture is contained. On the other hand the rays at the noon hours are more nearly perpendicular and pass into the solution from an oxidizing medium, the oxygen of the air. The reddening occurs only when the rays of light pass through the contact surface between

air and solution. This was clearly shown by sending rays through the solution in different directions by means of system of mirrors.

Dr. Bancroft then considered what the fundamental conditions are which make it possible for light to decompose the salt of a metal. If light according to Grothuss is analogous to a linear voltaic cell, its e.m.f. is very low, probably rarely exceeding half a volt. To get a photochemical reaction it is, therefore, necessary to start with a salt having a low decomposition voltage or to add something to the solution which will lower the decomposition voltage. In other words, we must add a depolarizer.

For example, ferric chloride in water is practically non-sensitive to light. In alcoholic solution it is reduced by light to ferrous chloride. The reason for the difference is that chlorine reacts readily with alcohol, but not readily with water. On the other hand, Grothuss found that ferric sulphate in alcohol was only acted on very slowly by light. The reason for this is that alcohol is not a good depolarizer for oxygen, but is a good one for chlorine.

The light-sensitiveness of all substances is increased by the presence of a suitable depolarizer, and, in many cases, we get light-sensitiveness only in presence of depolarizers.

An interesting case of a depolarizer is silver nitrate and silver iodide. The silver nitrate can react with an iodide and consequently make silver iodide more sensitive to light.

Further, the presence of the depolarizer and its nature really determine what the photochemical action will be. Whether a given substance is to be reduced or oxidized by light, depends on the nature of the depolarizer entering into the reaction. If the substance we are considering is in presence of a strong enough reducing agent, it will be reduced by light. If it is in presence of a strong enough oxidizing agent, it will be oxidized by light.

When light is absorbed by mercurous chloride, the mercurous chloride tends to disappear; but there is nothing in the action of the light *per se* to determine whether the mercurous salt shall be reduced to mercury or shall be oxidized to a mercuric salt. Either change involves the elimination of the mercurous salt. In presence of ether, sunlight reduces mercurous chloride to mercury. In presence of an oxidizing agent, light changes mercurous chloride to mercuric salt. When no especial reducing agent is present, the mercurous chloride acts as its own depolarizer and we get a mixture of mercury and mercuric chloride. Light tends to set free chlorine from silver chloride and light causes silver and chlorine to react. In most cases of oxidation, the reaction takes place in presence of air and the oxidizing agent is oxygen.

In this way it was shown by Dr. Bancroft that photochemical reactions are generally analogous to electrochemical reactions, and that the results of photochemical reactions can be reproduced under corresponding conditions by electrolysis. An interesting illustration was the production of "electrolytic photographs," that is the production of pictures on blue print paper by electrolytic means.

The paper was discussed by Prof. Baskerville, Prof. Burgess and Dr. Backeland. The latter spoke at some length on the great interest of photochemical research which should bring results of inestimable value. But the difficulties of this research are very great. If we want to imitate nature we have to do with exceedingly delicate reactions and have to employ nature's exceedingly delicate methods. Ordinary chemical analysis fails utterly in studying photochemical reactions. The most important photochemical reaction of nature is the observation of carbon dioxide from air by the chlorophyll of green plants. We know there is a magnificent system of regulation and a large surface for evaporation, etc., but we do not understand how the reaction goes on. As to the electrolytic photographs of Dr. Bancroft, he remarked that an accidental case of the production of such a cathode picture had once caused enormous trouble and expense to a photographic paper supply

company. Due to the presence of minute brass particles black spaces with a white ring around were produced on the sensitive paper which was thereby spoiled entirely. It was finally traced by Dr. Backeland directly to electrolytic action.

* * *

Forestry, Water Storage Power and Navigation.

The last paper of the evening session was presented by Mr. EDWARD R. TAYLOR, of Penn Yan, N. Y., on Forestry, Water Storage Power and Navigation. The author emphasized that the problems of preservation of our forest reserves, water storage and water power developments and navigation are all closely interconnected. They must be considered together from a broad point of view.

It is, for instance, a mistake to think that reforestation alone will solve the problem. While it may mitigate the disastrous floods occurring regularly in springtime and causing immense damage it will not prevent them. What is really needed, besides reforestation, is to build larger or smaller lakes in the upper country and impound the water so as to hold it back in time of flood and save the immense loss and damage, and at the same time produce highly valuable water powers and navigable rivers all through the dry summers.

This solution of the problem will be expensive, but it will more than pay the cost in the end. The water powers thus made available will be of very great value. The author thinks that the water power possibilities of the State of New York are more valuable than all the coal mines of Pennsylvania. It has been estimated by the N. Y. State Water Storage Commission that water power in New York State can be made to produce an annual profit of \$18,000,000, which, equals, if it does not exceed, the net profits of agriculture in this State.

To get up the money needed, the State or the Nation could advance it for performing the work and the people who are saved, the floods will gladly pay the taxes to refund the State or Nation; further, there will be a large income from the users of water power. The lumber that must be cut to give place for lakes will give the Forestry Department money with which to reforest the districts now deforested.

If these interconnected problems are to be solved they must be approached from a broad point of view. Mr. Taylor called attention to the excellent work which is being done by the New York State Water Supply Commission and by the American Forestry Association.

* * *

Kinetic Molecular Energy.

The first paper presented at the Friday meeting in Union University, Schenectady, was a lecture by Dr. CHARLES PROTEUS STEINMETZ, in which he showed that the familiar gas laws of thermodynamics can be derived from the conception of irregular molecular motion on the basis of the elementary principles of mechanics with the laws of probability.

The mental picture of irregular molecular motion is the foundation of the kinetic theory of gases. But while ordinary theory employs such artificial conceptions as collisions between perfectly elastic bodies, Dr. Steinmetz shows that there is no need for such assumptions. It is perfectly feasible to get all results by simply applying the laws of cosmic motion (sun, planets, comets) to molecular motion, without assuming any collisions.

The condition of molecular motion is chiefly determined by the velocity. According to the velocity of the molecules we have solids, liquids and gases. Within the lowest range of molecular velocity, the movement of the molecules is oscillatory; we have a fixed relative position; the body has a size or shape; it is a solid. Within the next higher range of molecular velocity, the velocity is able to carry the molecules just beyond the region of opposing forces; the molecules move in closed elliptic orbits (like the planets around the sun), the body loses its form and shape, but retains its volume; it is a

liquid. When the molecular velocity is raised still further, the molecules move in open parabolic paths; the body not only has no shape or form, but actually tends to increase its volume; it is a gas.

On the basis of these conceptions it is now easy to define the temperature and pressure of a gas in such a way that these definitions will directly lead to the familiar gas laws. The temperature is defined as proportional to one-half molecular mass multiplied by the square of molecular velocity. The pressure is defined as proportional to the number of molecules per unit of volume multiplied by molecular mass multiplied by the square of molecular velocity. Both definitions are very plausible in the light of the conception of molecular composition of matter. Dr. Steinmetz showed how by starting from these definitions it is easy to get directly the Boyle-Mariotte-Gay-Lussac laws and Avogadro's rule as consequences of elementary mechanics of molecular motion and the laws of probability.

In the same way Dr. Steinmetz discussed the expansion of a gas while performing external work and showed how the molecular conceptions lead to the familiar result that the decrease of internal energy equals the external work done. He then developed the law for adiabatic changes; first for monatomic gases, and then passed over to a discussion of molecules consisting of several atoms.

This part of the lecture was perhaps the most interesting and original, since it differed in essential points from the orthodox methods of the kinetic gas theory. In discussing the case where a molecule consisting of several atoms comes into the sphere of action of another molecule, Dr. Steinmetz started again from a cosmic analogy, namely, the force which scatters the swarm of meteorites or disintegrates a comet when coming into the sphere of influence of a sun. When our diatomic molecule is acted upon by another molecule, there will result a couple of forces, a rotary motion within our diatomic molecule. There will be a redistribution of energy, energy being transformed from orbital molecular motion into intramolecular motion, i. e., the motion of the atoms in the molecule. This transformation of molecular into atomic motion is determined by the principles of probability and in this way the familiar formulas can be derived.

The further away we are from the boiling point and the higher in temperature, the nearer we are to "ideal gases." That is, theory always gives us the laws for ideal conditions. Such laws contain "constants," which are constant for ideal conditions, but which vary in real processes. To determine the variation of these "constants" must always be one of the chief objects of research.

Finally, Dr. Steinmetz showed how elementary molecular mechanics and the laws of probability necessarily lead to the result that heat always moves from higher to lower temperature—which result is perfectly familiar to everybody, but can hardly be understood or explained in any other way.

* * *

Latent Heat of Vaporization.

Dr. JOSEPH W. RICHARDS, of Lehigh University, presented a paper on "the latent heat of vaporization." The metals, as far as they have been tested, pass into monatomic vapors, such as Na, K, Hg, Zn, and Cd, in which each atom represents a molecule. Trouton's rule, which is approximately correct for this case, states that the latent heat of vaporization of atomic weight is proportional to the absolute temperatures of the boiling point at atmospheric pressure, and is numerically equal to about 23 times that temperature, if the external work performed in overcoming the atmospheric pressure is included, or 21 times the absolute temperature of the boiling point if the external work is not included. From this rule we can estimate the amount of heat necessary to vaporize any metal the boiling point of which under atmospheric pressure is known.

Metallurgists, however, are often interested in the total heat

contained in the vapor when escaping under atmospheric pressure. This is 33 times the absolute temperature of the boiling point; it is the total heat required to raise the substance to the boiling point and boil it. This follows from the following approximate rules, which are often useful: If T is the temperature of the melting point and T^1 the temperature of the boiling point under atmospheric pressure, then the heat required to heat one molecule of the substance up to the melting point is $8T$, the latent heat of melting is $2T$, the heat raising the temperature from melting to boiling point is approximately $10(T^1 - T)$, the latent heat of boiling $23T^1$, hence total, by addition, $33T^1$; meaning in every case kilogram-calories per kilogram-molecule.

* * *

Electrochemical Patents.

Mr. A. B. MARVIN, Jr., of the General Electric Company, presented a paper in which he sketched the development of patent laws and the history of the Patent Office of the United States. A patent is a contract between the inventor and the people of the United States. What the people pay to the inventor is the monopoly for a limited time. The Patent Office is a barometer of activity in certain directions; for instance, when there is a war many patents are applied for for war supplies; similarly patents for crude oil burners in times of coal strikes, etc.

Mr. Marvin exhibited curves showing a number of electrochemical patents taken out each year since 1860. One curve comprised all sub-classes of electrochemistry, since 1860. There are now being issued about 280 patents on electrochemical subjects per year.

A second curve referred to battery patents, beginning with 1880. The curve has two maxima, one in 1890 and the other in 1900 to 1902; the latter has to be connected with the iron-nickel battery.

A third curve showed electric furnace patents beginning with 1902. There are yearly granted about 42 such patents.

The author referred to the bad conditions now existing in the United States Patent Office, with its steadily increasing work, and with an overworked and underpaid staff absolutely insufficient in number. The Patent Office has a yearly surplus so that there should be no lack of funds, and the force should be greatly enlarged. The trouble is really with the inventors and manufacturers who are willing to stand the present conditions. It is their own business to look out for a prompt and better transaction of business at the Patent Office.

In the discussion which followed, Mr. Louis C. Raegenor, of Dickerson, Brown & Raegenor, emphasized that what is really needed is a reform of the patent laws of the United States. Our present law affords no protection whatever to the inventor. They are only for the benefit of the patent attorneys. Though in his 23 years of practice he has won many suits for his clients, he has never recovered a really good judgment which would have compensated the inventor for all his troubles. It is different in England. Moreover, under present conditions this country is practically divided into nine countries in so far as there are nine circuit courts and a decision in one has no effect on the others. Dr. Potter referred to Germany where patent protection is much better. German law gives actual protection to the patentee. Dr. Steinmetz said it would be important to protect the inventor rather than the patentee. Dr. Baekeland referred to the treatment which an inventor gets when he offers a patent to a large company; he is talked to in such a way that when he leaves the office he feels almost like a criminal. Mr. Marvin, in closing the discussion, said that the German Patent Office has a staff three times larger than our Patent Office and grants fewer patents. Naturally, the German patents are stronger.

* * *

Electric Testing of Iron During Annealing.

Mr. E. E. F. CREIGHTON described a method of studying the effect of temperature during annealing on the magnetic prop-

erties of iron. The sample to be tested was made the secondary of a transformer so that it was possible to simultaneously heat the iron by induction currents and test it for its magnetic properties. With increasing temperature the permeability decreases. The magnetism disappears at a temperature slightly less than 800° C. The temperature was then raised higher and afterwards brought back, and the magnetism was found to come back at exactly the same temperature where it had disappeared before.

The apparatus was used for testing the iron in the atmosphere of various gases so as to determine their influence on annealing practice. Tests in an ammonia atmosphere showed bad effects, which are probably due to the nitrogen, since hydrogen seems beneficial. It is possible that this explains the difference between Bessemer steel and open-hearth steel for electrical purposes. Steels of these two brands, which, according to chemical analysis, have the same composition, may differ in their electromagnetic properties and this difference may be due to the nitrogen blown through the molten metal. These tests were made in the works of the General Electric Company.

In the discussion which followed, Dr. Steinmetz remarked that electrolytically refined iron is extremely hard and has a very high hysteresis loss, which may be due to the content of nitrogen. Prof. Burgess confirmed that electrolytic iron refined with an ammonium salt solution, indeed, contains nitrogen. Dr. Richards referred to Braunc's valuable investigations of the effects of nitrogen in iron (our vol. V, p. 51).

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Robert Hare's Electric Furnace.

A paper by Dr. CHARLES A. DOREMUS on Robert Hare's electric furnace was of great historical interest.

Robert Hare was formerly professor of chemistry at the

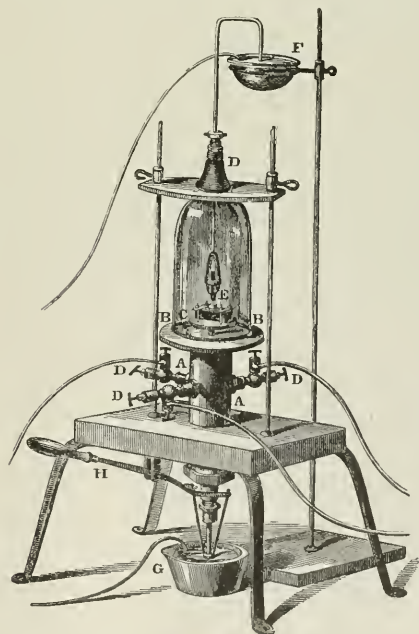


FIG. 4.—HARE'S ELECTRIC FURNACE.

University of Pennsylvania. Before the Chemical Society of Philadelphia (the first chemical organization of the world, founded in 1792) he announced in 1831, then but 20 years

old, his discovery of the oxy-hydrogen blowpipe. The properties of "Drummond's limelight" were known to him.

Hare later turned to electric heating. In 1831 he used electric heating of a platinum wire for exploding the charges of gunpowder in rock blasting from a distance. This means was afterward employed in England in blowing up the wreck of the Royal George.

Hare's first electric furnace, which was a vacuum furnace, was described by himself in 1839 in a paper before the American Philosophical Society entitled "Description of an Apparatus for Deflagrating Carburets, Phosphurets or Cyanides, in Vacuo or in an Atmosphere of Hydrogen, with an account of some Results obtained by these and other means; especially the Isolation of Calcium."

The energy for operating the furnace was derived from a battery of primary cells consisting of copper and zinc plates in sulphuric acid solution constructed on the principle of a plunge battery. The furnace is shown in Fig. 4, and is described as follows:

Upon a hollow cylinder of brass (AA) an extra air-pump plate (BB) is supported. The cylinder is furnished with three valve cocks (DDD), and terminates at the bottom in a stuffing-box, through which a copper rod slides so as to reach above the level of the air-pump plate. The end of the rod supports a small horizontal platform of sheet brass, which receives four upright screws. These, by pressure on brass bars extending from one to the other, are competent to secure upon the platform a parallelopiped of charcoal. Upon the air-pump plate a glass bell is supported, and so fitted to it, by grinding, as to be air-tight. The otherwise open neck of the bell is closed air-tight by tying about it a caoutchouc bag, of which the lower part has been cut off, while into the neck a stuffing-box has been secured air-tight. Through the last-mentioned stuffing-box a second rod passes, terminating within the bell in a kind of forceps, for holding an inverted cone of charcoal (E).

The upper end of this sliding rod is so recurved as to enter some mercury in a capsule (F). By these means and the elasticity of the caoutchouc bag, this rod has, to the requisite extent, perfect freedom of motion.

The lower rod descends into a capsule of mercury (G), being, in consequence, capable of a vertical motion, without breaking contact with the mercury. It is moved by the aid of a lever (H), connected with it by a stirrup working upon pivots.

Several of the experiments made by Hare are described from his original paper, and Dr. Doremus sums up his work as follows: "Hare obtained, despite the disadvantages of a current from a primary battery, calcium carbide, phosphorus, graphite and metallic calcium, and there are just reasons, therefore, for regarding him as the earliest American scientific experimenter and discoverer in electrochemistry."

* * *

Synthesis of Hydrocyanic Acid.

A paper by Mr. E. W. SMITH and Dr. R. S. HUTTON deals with the results of an experimental investigation carried out in the University of Manchester, England, on the direct synthesis of hydrocyanic acid and cyanides from carbon and gaseous mixtures such as producer gas, containing nitrogen and hydrogen (Brit. Patent 23835, Oct. 26, 1906; see also former work by James Dewar, *Proc. Roy. Soc.*, vol. 29, p. 188, 1879, and vol. 30, p. 85, 1880, and later work by H. von Wartenberg, *Zeit. f. Anorgan. Chemie*, vol. 52, p. 299, 1907).

While Dewar believed that the temperature of the electric arc was necessary for the reaction, the experiments of the present authors show that hydrocyanic acid can be formed at much lower temperatures.

The experiments of the authors were made in a closed vessel in which a rod of carbon was heated simply by Joulean heat, every precaution being taken to prevent arcing. In general, the experiments clearly prove that when carbon is maintained in contact with hydrogen and nitrogen below a temperature of

some 1800° C., cyanide is not produced in noticeable quantities.

On the other hand, at all temperatures above about 1800° C. the reaction proceeds, HCN is produced, and the carbon rod shows evident signs of attack, disintegrating to quite a marked extent; moreover, the relative quantity of HCN formed rapidly increases with the temperature, experiments having been performed at different temperatures ranging up to 2500° C.

In the case of using the carbon rod in an atmosphere of ammonia, the production of cyanide is, as might be expected, increased, but it is of some interest to note that the temperature at which the reaction occurs is not to any marked extent lower than with nitrogen and hydrogen.

Finally, the production of cyanides from mixtures of gases containing CO, such as correspond to producer gas, has been shown to proceed satisfactorily, and particularly in this latter case the process is of practical value, on account of the difficulty and expense of preparing pure nitrogen.

Some preliminary experiments in this direction were carried out in a furnace containing two solid carbon electrodes in a surrounding charge of ground carbon. The portion of the charge between the two electrodes is heated to the maximum temperature and it is there that the formation of hydrocyanic acid occurs. This is then quickly withdrawn and cooled with sufficient rapidity to preclude the decomposition of HCN. For this purpose either one of the electrodes is hollow and has a central channel through which the gas is withdrawn or a separate water-cooled tube is provided which projects into the central zone of the charge between the two electrodes.

The gaseous mixture of nitrogen and hydrogen together with carbon monoxide is supplied to the apparatus and passes through the carbon charge so that it is preheated. When it reaches the central part of the charge the reaction starts and the gas which is formed is then quickly withdrawn.

While these experiments are only preliminary in some respects, they prove definitely that HCN is formed at temperatures very far below that of the electric arc and under conditions which almost certainly preclude the intervention of complicated electric effects such as are characteristic of the arc.

Some of the records of a few typical experiments made by the authors are given.

* * *

Power for Electrochemical Industries.

A paper by Mr. JOHN MEYER was presented in abstract. The author is collecting statistical data, representative of the conditions in the more important central stations of this country, and also including data of the large power companies. These data are favorable to the supply of power from central stations to electrochemical works, but both parties—the central stations and the electrochemists—should understand each other. The electrochemist will be welcome as customer to the central station only if in that way the much-needed equalization of the load curve is obtained. Continuous electrochemical processes will not be suitable for such work, but only such processes as can be advantageously operated only at times of low load in the central station, or for about 20 hours a day. Central-station men and electrochemists should get together.

* * *

Alloying of Iron and Calcium.

At the Saturday morning session several interesting papers relating to metallic alloys were presented.

A paper by Messrs. A. HIRSCH and J. ASHTON, of the University of Wisconsin, was presented in abstract by Prof. Burgess. Former evidence as to the possibility of alloying calcium with iron is greatly conflicting. Many believe it cannot be done. The present authors have, however, succeeded in doing it and show that former failures have simply been due to the fact that calcium vaporized at the temperature of molten iron. But if calcium shavings are mixed with iron oxide in a closed, gas-tight steel cylinder and the charge is ignited, a very high pressure is produced within the cylinder and the vaporization point

of calcium is thereby reduced. It was thus found possible to include up to 6 per cent of calcium in the iron alloy.

However, such alloys are no good for practical purposes. Calcium in iron makes it very brittle. Even very little calcium makes itself very noticeable in iron. Calcium also destroys the welding properties of iron. The vaporizing point of calcium is between 1290° and 1300° C., and 1290° is assumed as the probable vaporization point at atmospheric pressure.

* * *

Calcium Alloys for Aluminothermic Work.

A paper by Dr. O. P. WATTS and Mr. J. M. BRECKENRIDGE, of the University of Wisconsin, on the preparation of calcium alloys for aluminothermic work was presented by Dr. Watts. In the reduction of refractory oxides by means of aluminium by the aluminothermic reaction of Dr. Hans Goldschmidt, the heat available for melting the reduced metal and the alumina slag is the difference of the oxidation heats of aluminium and of the metal to be reduced.

For the reduction of elements with a very high oxidation heat and a very high melting point, the reaction becomes more difficult. But there are several possibilities to improve matters. First the application of external heat, either by preheating the whole charge to a high temperature below the ignition point, or by adding the heat of the electric arc to that of the reaction.

Further, for industrial purposes, it is in some cases just as good to produce not the pure metal, but its ferro, for instance ferro-titanium. In this case Dr. Goldschmidt substitutes in his charge for a part of the oxide of titanium that of iron. Success is here obtained by the greatly increased heat of the reaction and the lower melting point of the ferro alloy.

The authors give a review of the various researches which have been made in recent years with respect to the aluminothermic process and then describe experiments made by themselves on the preparation of alloys of aluminium, calcium, magnesium and silicon, which they undertook with the hope of obtaining reducing agents which would possess a somewhat higher heat of oxidation per unit of oxygen than aluminium, and whose mixed oxides would form a much more fusible slag than alumina. It was also thought that there would be a decided advantage, so far as fluidity of the slag is concerned, in having the particles of the different oxides produced in intimate contact. This will be the case, to a far greater degree when the metals are alloyed, than when the different oxides are formed from isolated particles of each metal, as in a mechanical mixture.

Another object was to produce alloys of such brittleness that they could be easily pulverized to any degree of fineness (without using any special method, as in the case of aluminium).

Twenty-three different alloys of calcium with one, two or all three of the elements—aluminium, magnesium and silicon—were prepared by the authors. Their composition is shown in the table below.

No. of alloy Formula	1	3	4	5	6	7	8	9	11	12	14	15
Al	75%	74.5	45		60	CaMg ₂	50	AlCaSi	AlCaMg	AlCaMg ₂	Al ₄ Ca ₃ MgSi ₃	Al ₂ Ca ₂ MgK ₂
Ca	25	25.5	55	30	40	45.5	30	28.4	29.7	23.5	41.4	17.4
Mg				70		54.5	20	42.	43.9	34.8	15.8	51.6
Si								29.5	26.3	41.7	33.8	31.

No. of alloy Formula	16	17	18	19	20	21	22	25	31	32	33	34	35
Al	93.8	90	84	67.1	80	80	27.2	60	65	45	60	40	24.3
Ca	6.4	10	10	12.9	20	12.5	72.8	40		20	40	25	54.1
Mg			6			7.5			35	35		35	21.6
Si													

The alloys were made in an electric furnace of the granular-resistor type, by melting the constituents together in crucibles of Acheson graphite. The method of operation was as follows: The crucible was set in the furnace, sufficient calcium chloride added to form a layer over the metals when melted, and the elements put in in the following order: Aluminium, silicon, magnesium, calcium, each as soon as the one previously put in

had melted. Since the temperature was always much below the melting point of silicon, this element was taken up only by solution.

This was a rather slow process until the calcium or magnesium was added, when the silicon quickly dissolved. The alloy was stirred very thoroughly, and poured into a cast-iron mould. There was little trouble from burning of the calcium until this exceeded 70 per cent. In two attempts to prepare a calcium-aluminium alloy of over 85 per cent calcium, the alloy took fire and was lost. The time required to melt and pour a charge of about a pound varies from five to twenty minutes, depending on whether the furnace was hot or cold when the charge was put in, and upon the amount of calcium added.

Ten to twelve kilowatts was used for heating, although the current was often interrupted for a considerable portion of the time in order to keep the temperature to the lowest limit that would melt the metals. The alloys containing only calcium and magnesium were troublesome to prepare, as they were less dense than the protective layer of calcium chloride.

In appearance these alloys vary greatly, from the homogeneous glass-like structure of No. 6 (60% Al, 40% Mg), to the coarsely crystalline structure of No. 9 (28.4% Al, 42% Ca, 29.5% Si), which appears to be a mass of flat crystals $\frac{1}{8}$ in. x $\frac{1}{2}$ in. Their luster is metallic, and in most cases brilliant. They all decompose water at rates depending mainly on the amount of calcium or magnesium present. The addition of three drops of concentrated hydrochloric acid to 15 c.c. of water containing the alloys causes a considerable increase in the rate of evolution of hydrogen, and with the silicon alloys, yields a spontaneously inflammable gas, probably partly SiH₄. This causes sharp explosions in the test tubes.

The stability of the alloys in air is remarkable. After two weeks exposure in the laboratory, only one had disintegrated to an appreciable extent. As this alloy, No. 22, contained 73 per cent of calcium, its disintegration was to be expected. The other alloys appeared as bright as when made. This is in striking contrast to the rapid disintegration of copper-calcium alloys.

Several samples of these alloys were exhibited.

It is thus seen that alloys of calcium with aluminium and magnesium can be easily prepared up to a calcium content of 70 per cent.

All of the alloys prepared, containing 25 per cent or more of calcium or magnesium, can be readily pulverized.

Several of these alloys were then used in the aluminothermic reaction. The object was to reduce the compounds MoO₃, MoS₂, WO₃, SiO₂, Fe₂O₃, TiO₂ and mixtures of SiO₂ with MnO₂, of TiO₂ with MnO₂, and of TiO₂ with Fe₂O₃. The alloys so far tried are Nos. 8, 11, 14 and 15.

The first experiment was an attempt to reduce MoO₃ by alloy No. 8. The oxide was the usual fine powder of commerce, and the alloy is a mixture of all sizes that would pass a 20-mesh sieve. The reaction was very rapid, and was accompanied by

the projection of melted material, flame and much smoke. At the end of the reaction the crucible was nearly empty, and contained no metal. Thinking that the sudden expansion of air contained between the particles of the charge might be responsible for much of the loss of material, the experiment was repeated in a vacuum cylinder constructed from a piece of 8-inch steam pipe. Less material was projected than before,

but the loss was still great. Forty grams of well-fused molybdenum was obtained.

Several other experiments were tried in vacuo. SiO_2 was only partially reduced, yielding a brown product resembling silicon monoxide in appearance. A mixture of MnO_2 and SiO_2 , reduced by alloy No. 11 (AlCaMg), gave an excellent ingot of silicon-manganese, well separated from the slag. The yield was only 22 per cent of the theoretical, probably due to the large amount of material projected from the crucible. In order to reduce the velocity of reaction, pulverized fluorspar and lime were added to several charges, with a slight improvement in the yield of metal. After eight trials in the vacuum cylinder, experiments under atmospheric pressure were resumed.

Reduction of a mixture of MnO_2 and TiO_2 by No. 15 (AlCaMg_2), in pieces $\frac{1}{4}$ to $\frac{1}{2}$ of an inch in length, was violent, with much flame and smoke, and the projection of some slag. Only a few globules of metal were obtained. Other reactions were tried with quite similar results. The only alloy that gave quiet reactions was No. 14 (AlCaMgSi). This acted much like aluminium itself.

As a last resort the charges were fired inside a closed steel cylinder, designed to withstand a pressure of 10,000 pounds per square inch. With this apparatus, several difficult reductions were carried out. Mixtures of the alloys with molybdenite in theoretical proportions failed to react, but on adding a large excess of alloy and enough calcium peroxide to oxidize it, an ingot of well-fused metal was secured.

The most difficult reduction carried out was that of rutile. By the use of calcium peroxide, a single button weighing 15 grams, and many globules, were obtained. The metal is hard, though not sufficiently so to scratch glass. It is not in the least malleable, and is broken by severe pounding with a hammer. In appearance it resembles freshly broken Goldschmidt manganese. A qualitative test shows the presence of aluminium, apparently in rather small amount. It is hoped that further experiments may lead to the elimination of this impurity. Until this is attained the reduction cannot be considered a complete success.

All attempts to obtain tungsten from WO_3 failed.

The cause of the violent nature of the reductions by aluminium-calcium-magnesium alloys, whether carried out in air or in vacuo, whether the materials were coarsely or finely pulverized, was for some time very puzzling. The following explanation is offered:

When all the products of reaction are non-volatile, and no gases are present, it would seem that mere rapidity of reaction should not throw half the material from the crucible. If the cause does not lie in the volatile nature of some product, nor in the speed of the reaction, it must be sought in the original charge, and it is here that the authors believe that the difficulty lies—in the low boiling points of calcium and magnesium. The boiling point of Mg is given at 1100°C . and that of Ca as about 1300°C .

Besides confining the charge in a gas-tight cylinder, another method of preventing this vaporization of calcium was tried. Since calcium silicide is a product of the electric furnace, it ought to be stable at a very high temperature. It should follow that if all the calcium put into a thermit charge is in the form of calcium silicide, none of the metal can be evaporized until the silicide is decomposed by oxidation. When a molecule is broken up by attraction from outside, that element in it which has the greater affinity for the destroying agent is not the one which will "get left" in the struggle for oxygen.

Alloy No. 34 (40% Al, 60% CaSi) was prepared to test this theory. In two reactions with Fe_2O_3 , in open crucibles, there was no projection of material, and the reduction was very successful. The presence of this amount of silicon in the reducing agent, either free or combined, would greatly reduce the temperature attained. It is possible that the effect observed was entirely due to a diminished heat of reaction rather than to the reason assigned; yet the fact that the tem-

perature was high enough for iron to be perfectly fluid, leads the authors to consider these experiments as evidence in confirmation of their theory.

The cost per pound of materials entering into the alloys was: Aluminium, \$0.43; calcium, \$1.50; magnesium, \$1.25; silicon, \$0.15. The cost of materials in three of the alloys was: \$1.14 per pound for No. 11, \$1.36 for No. 15 and \$0.58 for No. 14. Silicon appears to be the only cheapening material at present available for addition to aluminium or its alloys, when they are to be used for aluminothermic processes.

The paper was briefly discussed by Messrs. Betts, Comey and Richards. In view of the fact that there is a tendency to substitute other elements for aluminium as reducing agent in the aluminothermic reaction, it was suggested by Dr. Richards to speak of the "metallothermic" reaction. Another name suggested was "elementothermic." It was stated that the manganese produced by Dr. Wahl, of Philadelphia, by reduction with aluminium, had some properties different from the present Goldschmidt manganese; this may have been due to contents of aluminium or silicon in Dr. Wahl's manganese. It was also suggested to use some of the alloys described in the paper for flash-light purposes.

* * *

Electrolytic Conduction.

A paper by Dr. LOUIS KAHLBERG, of the University of Wisconsin, was presented in abstract by Professor Burgess. Dr. Kahlenberg discusses the attempts which have been made to find out something concerning the nature of electrolytic conductors; that is, especially the question what other peculiar chemical or physical properties electrolytic conductors have, besides the one of conducting the current with concomitant chemical decomposition, to which the latter power may be ascribed.

Hittorf was of the opinion that electrolytes are salts (in the wider sense so as to include acids and bases). Arrhenius claimed that solutions showing abnormal vapor tension, abnormal lowering of the freezing point and abnormal elevation of the boiling point (where abnormal means a discrepancy from Vant' Hoff's gas theory of solutions) are electrolytes, and that in these solutions the dissolved substance is decomposed into positively and negatively charged part-molecules. However, Dr. Kahlenberg claims that this generalization does not hold true. As an example he mentions aqueous soap solutions, which boil at practically the same temperature as pure water, and yet are excellent electrolytic conductors. "The fact must calmly be faced that the vapor tension of solutions, and for that matter any other single physical property so far as we know, does not afford any basis whatsoever of a correct view as to the nature of electrolytes as contrasted with non-electrolytes."

In any consideration of the conduction of electricity the great fact that the best conductors are metals ever looms up before us. If an alloy is formed from two metals it is also a conductor. If a metal combines with an element or elements of non-metallic character, the resulting combination may be an electrolyte or an insulator. Tin is a conductor, chlorine an insulator. Stannous chloride is quite a good electrolyte when fused. Stannic chloride is an insulator throughout the entire range of temperature from the solid state through the melting point to the critical temperature and beyond. It looks as though the conducting power of the tin is gradually annihilated as more tin is added. "In general, one may say that every element tends to preserve its properties as it enters a compound, so far as the other ingredients in the compound will permit it to do so" or "as far as the new conditions, under which it is placed, in the compound will permit."

A great difficulty arises in explaining why certain substances and solutions which contain no metals at all conduct electrolytically and others do not. "One might well hold that the electrolytes which do not contain metals have yet a property characteristic of compounds containing metals * * * In this

category we have notably acids and salts of non-metallic bases. The hydrogen of acids has always been considered by chemists as having metallic characteristics, and the fact that liquid hydrogen has, after all, been found to be a non-conducting, colorless liquid, and solid hydrogen a colorless transparent solid has been somewhat disappointing to many chemists."

Further, it is not easily comprehended why in certain cases the union of two very poor conductors should result in a very good electrolyte. A typical example is the solution of acetic acid in water, which conducts well while the two pure substances alone are very poor conductors. But "all our notions as to the chemical constitution, so-called, of a compound are derived from the mode of building up or tearing down that compound and its behavior towards reagents. Our efforts to trace the power to conduct electrolytically to the chemical constitution of a compound are, therefore, simply efforts to find a relationship between electrolytic conductivity on the one hand and the behavior of the substance in question toward other chemical reagents on the other."

"We do not know why a piece of silver conducts and a piece of sulphur does not, though the experimental fact in question has been known for a long time; and we are really much more in the dark as to why some compounds conduct electrolytically, others do not conduct at all, and still others conduct without decomposition. A frank acknowledgment of the actual situation seems to me very desirable, for it is bound to stimulate inquiry that will lead to a better comprehension of the phenomena of conduction." We must have very much more intelligent experimentation on the subject of electric conduction in general and electrolytic phenomena in particular before we can hope for a real improvement of our theories of the interrelation of electricity and matter, and our views of the process of electrolysis and the nature of electrolytic conduction.

* * *

Direct Current in Electrolysis Without Electrodes.

A paper by Mr. CARL HERING suggests that experiments in which a direct current is made to flow through a complete circuit of electrolytes, without any electrodes, might answer some fundamental questions as to the nature of electrolytic conduction and the ionic theory. Mr. Hering described various experimental arrangements in which this result can be obtained.

The simplest way to produce a current in a complete circuit

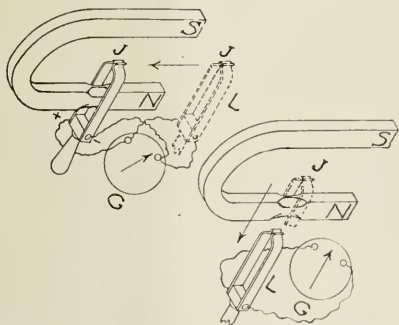


FIG. 5.—EXPERIMENT IN INDUCTION.

of electrolytes, without electrodes, would seem to be to induce it electromagnetically, as is done in transformers. But, according to the law of induction, as given by Maxwell and as usually stated in text-books, it would be impossible to produce a prolonged direct current in a closed circuit in this way, because it is, of course, impossible to continue indefinitely to increase (or decrease) the magnetic flux enclosed by such a circuit; and according to that law as it is usually stated, it would be impossible

to alternately increase and diminish this flux without producing an alternating current.

But Mr. Hering has recently shown* that the law as usually stated, is incorrect. It is possible to get a direct current by repeated cutting of the same flux, namely, by cutting it in one direction with the conductor and in the reverse direction with the circuit only, the conductor remaining at rest, relatively to the flux. (See foot note.)

Another method is suggested by a recent experiment of Dr. Northrup (*Phys. Review*, vol. 24, June, 1907). Two bar magnets are mounted radially in a vertical beaker containing an electrolyte, with like poles toward the central axis, around which they are capable of rotating. If now a current is passed vertically through the electrolyte, these magnets will revolve, owing to the horizontal circular lines of flux in the electrolyte, due to the current.

Reversely, Mr. Hering concludes, a direct current will be induced in the electrolyte, if the magnets are revolved by an external power.

Various other arrangements, which may be used to advantage for experimental research, are also described in some detail, but no such experiments have yet been actually carried out.

The paper was briefly discussed by Messrs. Bancroft, Breed, Burgess, Ladbury and Richards.

* * *

Reversed Electrolysis.

A paper by Mr. J. W. TURRENTINE, of Cornell University, was presented in abstract by Dr. Bancroft. It dealt with apparently abnormal reactions at the electrodes of an electrolytic cell. A case in point is the deposition of gold from an alkaline carbonate solution on the anode. We have here to do with a secondary precipitation of gold from the primary anodic product of electrolysis. Under certain conditions it is also possible to produce hydrogen at the anode and oxygen at the cathode. Various cases of this kind were described and explained. The paper was briefly discussed by Messrs. Betts and Ladbury.

* * *

Dry Cells for Ignition.

A paper by Dr. J. W. BROWN, director of the Research and Battery Laboratory of the National Carbon Company, dealt with the use of dry cells on ignition service. While the dry battery was early in the ignition field, it has often been used, and is still being used, in a very inefficient manner, so that some operators of gas or gasoline engines have turned to the storage battery. But things will be different when the proper use of dry batteries is better understood.

Most gas or gasoline engines are equipped with an ignition apparatus consisting of a spark plug, a transformer spark coil and a make-and-break device or timer. It is the function of the timer to close the battery circuit through the primary circuit of the spark coil at the proper moment in the engine cycle and for a sufficient period or interval to allow the current to rise to such a value as to be capable of being transformed by the spark coil into one which will pass the spark gap in the engine and ignite the explosive mixture of gases. The battery circuit:

**Proc. Am. Inst. Elec. Eng.*, March, 1908, p. 339. Mr. Hering's fundamental experiment is as follows: A loop L, in the left-hand diagram of Fig. 5, was formed of two flexible strips whose ends, pressed together at joint J, and the circuit of the loop was closed through a galvanometer G. On moving this loop over one leg of a U-shaped permanent magnet NS from the dotted position to that shown in full, an electromotive force was induced, as is well understood. The magnetic flux has thereby been linked with the electric circuit, the flux enclosed by the circuit has been increased from zero to the maximum; or, to use Faraday's terms, the lines of force in the air from one pole to the other have been cut by the conductor. If this loop is now moved, as shown in the right-hand diagram from the dotted position to the one shown in full, by passing the leg of the magnet through the joint J of the loop, but without opening the circuit, the flux and the circuit will be unlinked again; that is, the flux enclosed by the circuit will again be reduced from a maximum to zero, and the circuit will have cut the same lines of force in the opposite direction, as it is well known that all the flux of this magnet passes through its interior. But there is absolutely no e.m.f. induced by this unlinking. To get an e.m.f. it is necessary that the conductor itself (not the circuit) cut the lines of force; and it is thus necessary to distinguish between conductor and circuit.

should be closed through the coil only for exactly the right period to prevent a waste of battery energy.

From the standpoint of the efficient use of dry battery energy the usual types of timers are faulty in having excessively long contacts, variable with the speed at which the engine is running, and the usual types of spark coils are faulty in requiring too high an amperage per spark, and in producing too many sparks per explosion. The magnitude of the waste of battery energy from these sources is evident from the following comparisons:

Efficient ignition can be produced with a contact of a duration of 0.005 second and with a single spark per explosion at all speeds of the engine. The resulting drain on the battery corresponds to a continuous current of about 0.05 of an ampere. In spite of these facts the period of contact of the chief forms of timers varies from 0.01 to 0.05 of a second, according to the speed at which the engine is running, and the number of sparks given by the most-used types of spark coils varies from 4 to 10 or 15 per explosion. The resulting drain on the battery corresponds to a continuous current of 0.3 to 0.6 of an ampere when the engine is running and the vibrator of the spark coil is properly adjusted. In some cases which have come to Dr. Brown's attention the drain was increased, by faulty adjustment of the vibrator alone, from about 0.5 to over 3 amperes. These statements were illustrated in a very interesting way by means of apparatus exhibited at the meeting.

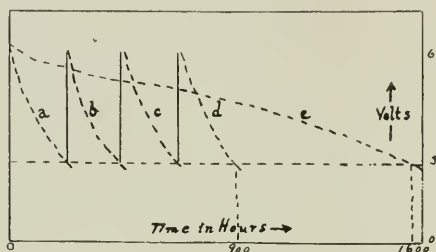


FIG. 6.—DISCHARGE CURVES.

Dr. Brown has found that over 90 per cent. of the trouble experienced with battery ignition is due to the use of poorly designed ignition apparatus or the use of well-designed apparatus badly adjusted.

The ignition apparatus should consist of a spark plug of the usual types, of a single transformer spark-coil with a mechanical make-and-break in the primary circuit driven by, but independent of the speed of, the engine, and of a distributor which sends the induced high-potential current to the various cylinders of the engine in rotation. Such an apparatus would produce a single hot spark per explosion.

Turning now to the dry battery itself, Dr. Brown emphasized that the chief requirement of a dry battery for ignition service is not simply to furnish a given quantity of electrical energy, but to furnish it in the form of impulses of 2 amperes or more in rapid succession through a resistance of about 0.5 ohm.

Initial amperage and initial voltage readings so widely used in dry battery tests, do not serve to disclose the ability or lack of ability of the dry battery to give long ignition-service life. While the available energy is an important factor, the internal resistance, not of the unused battery, but of the battery while on service, is a second important factor in determining the value of the battery for gas-engine work, and the size and arrangement of cells in the battery necessary for best results. In this second respect two cells, with the same available energy, may differ greatly, as was shown by curves. The difference is caused by the increase in internal resistance due to mechanical clogging of the cells during discharge—and is only developed by actual discharge.

According to present standards and present methods of using dry cells, i. e., in the form of a single series of cells or battery,

the one cell may and the other cell may not be capable of giving good ignition service. If, however, both types of cells were used in the form of series parallel batteries of two, three or four sets of cells in parallel, not only would practically the same good service be obtained from each type, but also in each a very much longer service would be obtained than when used in batteries of a single series.

This is evident from the discharge curves shown in Fig. 6, where curves *a*, *b*, *c* and *d* represent the decrease in working voltage of four single series batteries of four cells each similar to present ignition practice, while curve *e* represents the decrease in working voltage with four batteries of the same kind connected up in parallel to form a single series-multiple battery in which the average drain and the impulse required from each cell is reduced to one-fourth of the corresponding values required from each cell in the single series batteries. A gain in service life of 100 per cent. is shown.

It is a natural conclusion from such results that, both in respect to reliability and in respect to length of service life, dry cells of the 6-in. size should not, except in case of emergency, be used in the form of a single series battery, but instead they should be used in the form of series-multiple batteries with as many as four sets in multiple whenever possible. Practically all dry battery troubles not caused by the use of ignition apparatus of poor design or adjustment may be located in the use of a battery of a form and size not adapted to the service required of it. Given a good ignition apparatus and a battery of proper size and form, dry cells are capable of furnishing electrical energy for gas or gasoline ignition with an economy and a reliability exceeded by no other means now in general use.

In the discussion which followed, President Burgess remarked that, from an industrial point of view, the dry cell is a very important electrochemical piece of apparatus, there being used in this country from 30,000,000 to 50,000,000 dry cells per year. The usual test of taking a reading of the initial amperes by short-circuiting the cell through an ammeter is really foolish, but for the sake of competition manufacturers build their dry cells so that they give high initial values and must jeopardize to some degree other more valuable qualities. Some remarks by Messrs. Hering, Fleming and Brown referred to details of the electrical tests made in this investigation.

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Electrolytic Corrosion of Aluminium Bronze.

A paper by Mr. W. S. ROWLAND, of Cornell University, was presented in abstract by Dr. Bancroft. The paper gives the results of an experimental investigation of the corroding effects of the more common sodium salts and of sodium hydroxide upon aluminium bronzes of different composition. The results are interpreted with the aid of the equilibrium diagram of phases. It is shown that unless caused by some additional chemical action, the changes in the rates of corrosion only occur upon the appearance or disappearance of a phase, as shown in the equilibrium diagram. It is possible that the alloy containing from 10 to 20 per cent copper may be very serviceable for metal parts which are subject to the weather.

* * *

Corrosion of Bronzes.

Dr. A. T. LINCOLN, of the University of Illinois, presented in abstract an account of further researches on the electrolytic corrosion of the bronzes. He has formerly made detailed and very elaborate investigations on this subject, which may be found in full in Vol. XI, p. 43 of the *Transactions of the American Electrochemical Society*. While he had formerly studied corrosion by different separate salt solutions, he has now made tests in a mixed solution, namely, in synthetic sea water. The curves showing the results are quite in accordance with his former results. The corrosion in sea water is of the same general character as corrosion in a sodium chloride solution.

Electric Distillation of Turpentine.

A paper by Mr. F. T. SNYDER, who is best known by his activity in electric zinc smelting, deals with a plant in which turpentine is distilled by electricity on a commercial scale in Canada.

Pine woods contain a series of volatile hydro-carbons having boiling points varying from $130^{\circ}\text{C}.$ to $250^{\circ}\text{C}.$ A mixture of these, including the groups which boil between $155^{\circ}\text{C}.$ and $170^{\circ}\text{C}.$, forms what is commercially known as turpentine. The principal constituent of this turpentine is pinene, with a boiling point of $155^{\circ}\text{C}.$ to $156^{\circ}\text{C}.$ The process of obtaining turpentine from wood by distillation is an expensive one, in that the turpentine exists in the wood substantially in the form in which it is obtained, and is not a product of decomposition at the time of extraction. At $175^{\circ}\text{C}.$, the pinene of the turpentine begins to break up into a mixture of lighter and heavier hydro-carbons, the decomposition being substantially complete at $270^{\circ}\text{C}.$ It is therefore necessary to distill turpentine within relatively narrow temperature limits.

The plant is erected at Vancouver, B. C., where a considerable supply of waste fir wood is available in the form of saw-mill refuse and cheap electric power is also available. The plant has a capacity of three cords per day and has been in operation since July, 1907.

The wood supply for this plant is brought in by barge from neighboring sawmills, and landed at a dock adjoining the plant. On this dock the wood is filled into cans, which are wheeled into the plant, picked up by an overhead crane and dropped into a brick retort, forming one of a group which are placed together to reduce radiation. The top of the can forms a flange, which dips into a groove around the top of the retort, filled with tar, forming a gas seal when the can is in the retort. Electricity at 110 volts is carried through wrought-iron strips threaded through the brickwork on each side of each retort.

By means of direct reading pyrometers the temperature outside of and at the center of the can is measured. The turpentine vapor which is distilled off is taken from the retort through a removable copper outlet pipe to the condenser, which consists of an upright copper pipe, down which a spray of water is passed through the ascending turpentine vapor, and which terminates in a tank at the bottom. The tank serves as a separator for the condensed turpentine and water, the turpentine readily floating to the top of the water.

The brickwork of the retort, when a can newly filled with wood is put in it, is about $250^{\circ}\text{C}.$ The cold can rapidly absorbs heat from this brickwork, the temperature of the brickwork being kept up by a current of 400 amperes, which is put through the resistance strips for about two hours. During this time, the temperature at the outside of the can rises from 75° to $130^{\circ}\text{C}.$, at which turpentine begins to come off and at which time the center of the can is at $45^{\circ}\text{C}.$ The current is then shut off, and the temperature of the can slowly rises by absorption of heat from the brickwork for two hours longer, when the temperature has reached $150^{\circ}\text{C}.$ on the outside of the can and $205^{\circ}\text{C}.$ in the center of the can and the turpentine has been substantially all removed. In practice it is found that from 90 to 95 per cent. of the turpentine in the wood, as determined by analysis, is removed during this interval. While the turpentine is coming off, the pitch in the wood melts and runs down to the bottom of the can and out through perforations, and is collected in the bottom of the retort, from which it is drawn off, at the end of the run, into the barrels in which it is shipped.

The fact that the temperature at the center of the can at the end of the turpentine run is higher than outside is due to the decomposition of the hydro-carbons in the woods, which reaction liberates heat. In order to keep the turpentine condenser and piping from being fouled by tar oil or tar products, it is therefore necessary to lift the can now by the overhead crane from the turpentine retort and put it into an adjoining retort.

In its new position the can is now connected up by another

copper pipe to a second condenser and due to the continuous decomposition of wood with rising temperature, without any further use of electricity, tar oil goes off as vapor and is condensed while wood tar trickles down (as the rosin does in the turpentine retort) and is collected in the bottom of the tar retort.

At the end of three hours of the tar run, the temperature in the center of the can has risen to $375^{\circ}\text{C}.$ and tar oil and tar stop coming off. The can is then lifted out and stood on a sand floor, which makes an air seal with the lower edges of the can and protects from combustion the contents of the can, which now consists of charcoal. When the can and its charcoal contents are cool, which takes about three hours, the perforated bottom of the can is tripped and the can lifted, allowing the charcoal to fall out. This charcoal is then put in sacks, as required by the trade which consumes it. The charcoal is tough and suitable for special purposes.

In practical work there are obtained per thousand pounds of wood 67 gallons of turpentine, 168 pounds of rosin, 5.1 gallons tar oil, 68 pounds tar and 323 lb. charcoal. There are used 90 kw. hours per can of a thousand pounds of wood and the cost of these 90 kw. hours at Vancouver is 18 cents only. The plant is operated by one man on each shift, there being two 12-hour shifts per day. When the wood is large an extra man is employed on the day shift to split it.

* * *

Concentration of Mixed Sulphide Zinc Ores.

A paper on the corrosion of iron pyrites into a magnetic form by Mr. O. L. KOWALKE, of the University of Wisconsin, was presented in abstract by Prof. C. F. Burgess.

One of the important problems in preparing mixed sulphide zinc ores for the smelting operation is the removal of iron pyrites. A method commonly employed for removing the iron pyrites is first to convert the non-magnetic sulphide to a magnetic form by roasting the ore in a furnace where the products of combustion come in direct contact with the ore. After cooling, the roasted product is treated by a magnetic separator.

In this roasting process some of the ore frequently becomes heated to an excessive temperature, and in the presence of oxidizing gases, red oxide of iron is formed which is non-magnetic. The purpose of the investigation described in this paper was to determine the temperature and the various atmos-

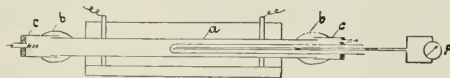


FIG. 7.—ELECTRIC FURNACE.

pheric conditions under which iron pyrites can be made magnetic; also the loss of sulphur necessary for the attainment of this condition.

The experiments were made in a granular carbon resistance furnace of the construction shown in Fig. 7.

The furnace, whose inside dimensions were 3 in. x $2\frac{1}{2}$ in. x 13 in., was built of fire brick. A Royal Meissen Porcelain tube (a), 26 inches long, one inch internal diameter and glazed on the inside, served as the chamber in which the ore was treated. This tube, surrounded by the graphite resistor, lay lengthwise in the furnace. The furnace terminals were graphite slabs straddling the tube. To provide for suitable stoppers for the ends of the tube, glass sleeves (c), about 3 inches long, were slipped over the ends of the porcelain tube and cemented on by a mixture of magnesia and water glass (b). Besides providing for a stopper of sufficient size to admit the placing of inlet and outlet tubes, these glass ends served also to prevent heat conduction from the porcelain to the stopper.

A thin layer of charred paper around the tube served to prevent any pitting action on the porcelain by the hot resistor particles even at temperatures above $1000^{\circ}\text{C}.$

An alternating current at about 33 volts was sufficient to give

the heat desired. The voltage, when applied to the furnace, brought the tube up to temperature quickly, and then by regulating the voltage, the temperature was maintained easily within 10° C. of the point desired.

The temperature was measured by a Le Chatelier pyrometer with galvanometer. P. A. Kipp gas generator served for supplying the gas necessary for the various tests.

The electromagnet used was 2½ inches external diameter and 6 inches long. With a magnetizing current of 6.2 amperes in the winding, a flux was obtained sufficient to hold up 4830 grams of soft iron.

In all cases the material used was pure marcassite. This was crushed and sized, and that portion which passed a 20-mesh sieve and caught on a 40-mesh, was used for the tests. Great care was taken in the handling of the furnace and in the measurements made. After sealing the furnace the gas in which the ore was to be tested was passed through for at least 20 minutes to insure complete expulsion of air before the current was applied. The furnace was heated slowly to insure an even distribution of heat; this usually took an hour or more.

When the desired temperature was attained it was kept at that value within about 10° C. by regulating current and voltage on the furnace. After the ore had been treated a sufficient length of time, the current was cut off, but the gas allowed to pass through the tube until the temperature had fallen to at least 180° C. before the tube was opened. The ore was then removed and tested under the magnet for magnetic qualities. In all cases the magnetizing current was kept close to 6.2 amperes.

For testing in air the procedure varied somewhat from the general scheme; the heating tube was open to the air at one end and the ore was roasted in a closed cylinder to avoid too much exposure to oxidation. A cylinder of iron $\frac{3}{8}$ in. diameter and 1 in. long, closed at both ends, with the exception of a small hole to allow the escape of fumes, proved unsatisfactory.

The sulphur vapors, which were driven off, attacked the iron and a fluxing action between the iron and ore took place so that it became impossible to account for losses. A porcelain cylinder of the above size, whose ends were closed by stoppers, each with holes of 1.32 in. in diameter, gave the best results. Thus an atmosphere composed of sulphur vapors and air was attained.

The furnace was first brought up to temperature and then the charged cylinder put in the tube. After heating the cylinder and charge this was taken out into the air and left to cool. When cool the separation tests were made with the magnet. The magnetic portion varied in color from a black to blue-black, while the non-magnetic residue was yellow.

In these tests made at atmospheric pressure the ore became magnetic at about 700° C. When the atmospheric pressure was reduced by about 45 mm of mercury, the ore became magnetic at a temperature about 150° lower than under atmospheric pressure and in half the time. The appearance of the roasted ore particles was bluish black. Only the outside layer of the particles had changed color, for the inside was yellow and apparently unaffected.

Tests were then made in an atmosphere of hydrogen (made from electrolytic iron and hydrochloric acid). In this case marcassite began to be changed to a magnetic sulphide at the low temperature of 494° C. The resultant grains are blue-black in color, due to a thin magnetic layer, for the inside was still yellow. Another interesting observation made in these tests was that hydrogen sulphide still seems to exist at the high temperature of $1,172^{\circ}$ C.

The next series of tests were made in carbon dioxide. Sulphur vapors appear at about 507° C. The marcassite is made magnetic at about 600° C. or somewhat less. In an atmosphere of carbon monoxide marcassite is rendered magnetic at a temperature about 80° lower than in carbon dioxide. From these tests it also seems possible that FeS_2 can be reduced to metallic iron by carbon monoxide at a temperature below 600° C.

Finally tests were made to determine the temperature at which sulphur is given off.

The chief results of the paper are summed up as follows: "It is not necessary to roast pyrite or marcassite to a homogeneous mass in order to obtain a magnetic product. A loss of sulphur of from 3 to 12 per cent. is sufficient to produce a coating, such that its magnetic properties will cause the whole particle to be picked up.

"Roasting in a reducing atmosphere and under a slightly reduced pressure requires a lower temperature than in a neutral atmosphere, and causes a smaller loss of sulphur to form a magnetic product.

"In a neutral atmosphere, sulphur begins to distil from FeS_2 at about 510° C. and continues to come off up to about 680° C. The roasting could be stopped slightly above 600° C., providing the atmosphere is neutral. If the temperature is increased beyond 680° C. the sulphur is driven off until FeS_2 results.

"Marcassite can be reduced to metallic iron in an atmosphere of hydrogen."

* * *

Electrolytic Refining of Iron.

A paper by Dr. EDWARD F. KERN, of the Department of Metallurgy, School of Mines, Columbia University, deals with the electrolytic refining of iron. The author first gives a review of what has been done before in this field, especially by Burgess and Hambuechen (see our Vol. II, p. 183) and others, and then gives the results of an experimental research carried out by him with the following electrolytes: (a) Solution of ferrous sulphate; (b) solution of ferrous sulphate containing sodium sulphate; (c) solution of ferrous chloride containing sodium chloride, and (d) solution of ferrous fluosilicate.

The fluosilicate was selected, as this iron salt is very soluble in water and since it had been found that neutral electrolytes of nickel fluosilicate give very flexible, bright and smooth deposits of nickel, it was hoped that the same would be the case with iron. The electrolytes were made up as follows:

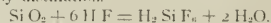
(a) The ferrous sulphate solution contained 40 grams $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ per 100 cc., giving an electrolyte containing about 8 per cent. of iron (8 grams Fe per 100 cc.). (Solubility: 100 cc. of water at 20° C. dissolve 48.3 grams $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$.)

(b) The ferrous-sodium sulphate solution contained 30 grams $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ and 21 grams $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ (Glauber's salt) per 100 cc., giving a solution containing about 6 per cent. of iron and 3 per cent. of sodium. (Solubility: 100 cc. water at 20° C. dissolves 44 grams $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$.)

(c) The ferrous-sodium chloride solution contained 28.5 grams $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ and 10.2 grams NaCl per 100 cc., giving an electrolyte containing 8 per cent of iron and 4 per cent of sodium. (Solubility: 100 cc. water at 20° C., dissolves 64.3 grams $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$; 100 cc. water at 20° C. dissolves 35.8 grams NaCl); 1 cc. conc. HCl per 100 cc. electrolyte was added in order to clear the solution.

(d) The ferrous fluosilicate (FeSiF_6) solution was prepared by taking a calculated amount of dilute fluosilicic acid, containing 31 per cent. of H_2SiF_6 , and neutralizing it with metallic iron, short-circuited with a strip of platinum, similar to an electric cell. The temperature of solution was kept between 55 and 65° C. until it was almost neutralized. Below 40° C. the reaction was very slow. (A small amount of free acid was left.) The nearly neutral solution of FeSiF_6 was diluted so as to contain about 8 per cent. of iron. It was of light green color, clear, and did not oxidize so rapidly as the solutions of ferrous sulphate and ferrous chloride.

The fluosilicic acid was prepared by digesting a calculated amount of pulverized quartz in a platinum dish with hydrofluoric acid solution, containing about 35 per cent. HF. The reaction produced sufficient heat to cause the solution to boil. It was cooled by adding a small amount of water, to prevent loss of SiF_4 by distillation.



The FeSiF_6 solution was kept in an ordinary glass bottle,

and the electrolysis was conducted in glass beakers. There is scarcely any corrosive action of the solution on glass.

The results of the experiments of the author are given in great detail in form of tables. They are summarized as follows:

Neutral ferrous fluosilicate electrolytes are not suitable for electrolytic refining of iron, as they are slowly decomposed with the separation of silica, which settles to the bottom of the cell and also collects in the anodes and cathodes.

The deposits from ferrous fluosilicate electrolytes are smooth and solid, of dull gray color and very brittle, due to the contained silica.

The e.m.f. required for electrolysis of ferrous fluosilicate electrolytes with a current density of 10 to 20 amperes per square foot was 0.9 to 1.2 volt when the temperature was 20° C., and 0.55 to 0.70 volt when the temperature was 60° C.

Good deposits of iron were obtained by the electrolysis of neutral electrolytes containing either 8 per cent. of iron as FeSO₄, or 6 per cent. Fe and 3 per cent. Na as sulphates, or 8 per cent. Fe and 4 per cent. Na as chlorides.

The e.m.f. required for electrolysis of neutral FeSO₄ electrolytes containing about 8 per cent. Fe with a current density of 10 to 20 amperes per square foot was 1.15 to 1.40 volt when the temperature was about 20° C., and 0.80 to 0.98 volt when the temperature was about 50° C.

The e.m.f. required for electrolysis of neutral sulphate electrolytes containing about 6 per cent. Fe and 3 per cent. Na, with a current density of 10 to 20 amperes per square foot, was 0.95 to 1.20 volt when the temperature was about 20° C., and 0.50 to 0.85 volt when the temperature was about 50° C.

On starting the electrolysis of sulphate and chloride electrolytes, the deposits of iron peeled from the cathode and curled, due to the presence of ferric salts in the solution. After the solutions were electrolyzed for about three hours the deposits formed smooth, solid and adherent.

Boiling the solutions previous to electrolysis liberated the dissolved gases and caused the deposits to form less pitted.

The deposits of iron formed smoother when the electrolysis was conducted at 40 to 60° C. than when conducted at normal temperature.

The deposits formed in neutral chloride electrolytes, containing iron and sodium chlorides, were finer grained and more flexible than those formed in neutral sulphate electrolytes.

The deposits of iron formed in neutral sulphate or chloride electrolytes, containing no ammonium salts, became quite malleable when they were heated above redness. The deposits from the chloride electrolytes, being finer grained, were the most ductile and could be hammered double after being heated.

The deposits of iron from electrolytes containing ammonium salts were harder, more brittle and also less rapidly oxidized than those from electrolytes which contained no ammonium salts. This suggested the possibility that deposits of iron formed in neutral ferrous-ammonium electrolytes contained either a nitrate or an ammonium compound of iron.

When the electrolytes are not protected from the atmosphere it is necessary to occasionally add a few drops of acid in order to clear the solution by dissolving the resulting basic salts.

When the electrolytes are not in use they may be maintained in the ferrous condition by placing in stoppered bottles and adding a few pieces of wrought iron, either wire or strips.

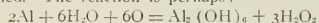
In the discussion which followed, Dr. J. W. Richards expressed the opinion that the time had come to start electrolytic iron refining on a commercial scale, the electrolytic iron product to serve as raw product for the manufacture of carbon-free ferroalloys and high-grade special steels. Since the process does not seem to be covered by patents, there is nothing more required than a little missionary work and some commercial enterprise. Prof. Burgess pointed out that while his process had been in satisfactory operation continuously for several years in his laboratory, yet in carrying it out on a commercial scale some new problems would come up which would have to be solved. Nevertheless, the cost of refining would be low. As to Dr.

Kern's paper, it was important to know that chloride solutions gave satisfactory deposits, since they were superior to a ferrous and ammonium sulphate solution, as they could not produce any content of nitrogen in the iron. But Dr. Kern's experiments had not been carried out for a period long enough to say how the methods would work in continuous operation on a commercial scale.

* * *

Surface Film on Aluminium.

The last paper presented related to the nature of the surface film formed on aluminium and magnesium and the aluminium and magnesium cell (concerning which see *Transactions Amer. Electrochem. Soc.*, vol. X, p. 55), the authors being Dr. H. T. BARNES and Mr. G. W. SHEARER, of McGill University. Oxygen dissolved in the electrolyte on the surface of aluminium plays an important part. The aluminium reacts with the dissolved oxygen to form H₂O₂; hence the addition of this reagent to the cell which was formerly shown to augment the e.m.f. only increases the concentration of the substances already formed. The reaction is perhaps:



This suggests the nature of the film which is formed on the surface of aluminium when exposed to moisture and which plays an important part in the aluminium rectifier.

If a current is passed through the cell making the aluminium an anode, then the reaction is hastened, more peroxide is formed, and more hydroxide is produced. If the aluminium is cathode, as it is in the normal working of the aluminium-magnesium cell, then the peroxide is reduced and the film removed. Hence, when short-circuited the resistance of the cell is much reduced and the current increased, the e.m.f. being that produced by the presence of hydrogen peroxide around the aluminium.

Schulze has recently studied other metals with respect to non-symmetric conductivity. This he attributes to a thin layer of gas or oxide on the surface, which gives rise to various effects.

The fact that H₂O₂ may be produced in measurable quantities when aluminium is immersed in pure water charged with oxygen and not in oxygen-free water indicates directly the nature of the surface film which is formed and which has been the subject of so much discussion by previous observers.

In the discussion which followed, Dr. Whitney asked for information how the aluminium rectifier works in practice. Prof. Burgess said that it was very promising before the arrival of the mercury-vapor rectifier. But the aluminium rectifier has one great disadvantage, namely, that in course of time the aluminium disintegrates and the solution changes. Disintegration of the aluminium takes place whether an aqueous or a fused electrolyte is used. There are no actual data published concerning use of electrolytic rectifier over a long time. The quality of the aluminium appears to be a factor determining the life of the rectifier.

* * *

A vote of thanks was then adopted to the individuals and companies who, through the many courtesies shown to the society, had made this meeting so successful.

The retiring president, Prof. C. F. Burgess, then introduced the president-elect, Mr. E. G. Acheson, who thanked the society in a few well-chosen words and asked that all members should show their loyalty to the society by attending the meetings and contributing to the *Transactions*. A man's value is not determined by what is in him, but what proceeds from him. An inventor should protect himself as far as patent laws permit, but after he has done so, Mr. Acheson recommends not to be afraid of publicity. "Take the public into your confidence and they will protect you. The public in general is trustworthy and just." He asked the members to contribute accounts not only of their successes or hoped for successes, but also of their failures. Every experiment must be considered a

success if it only shows what can be done or what cannot be done.

The meeting then adjourned. The next convention will be held about the beginning of October in New York City.

The following is a complete alphabetical list of all members and guests who registered at the meeting:

Edward G. Acheson and Raymond M. Acheson, Niagara Falls, N. Y.; George P. Adamson, Easton, Pa.; Alex. O. Appelberg, Schenectady, N. Y.; Mr. and Mrs. William C. Arson, Schenectady, N. Y.; W. C. Andrews, Schenectady, N. Y.; H. Backeland, Yonkers, N. Y.; Wilder D. Bancroft, Ithaca, N. Y.; H. Barker, New York City; Charles Baskerville, New York City; Frederick M. Becket, Niagara Falls, N. Y.; John W. Beckman, Schenectady, N. Y.; McV. Bennie, Niagara Falls, N. Y.; E. J. Berg, Schenectady, N. Y.; R. Berry, Lynn, Mass.; Anson G. Betts, Troy, N. Y.; E. Blough, Pittsburgh, Pa.; R. W. Boyle, Montreal, Canada; W. C. Bray, Boston, Mass.; George Breed, Philadelphia, Pa.; Howard L. Bronson, Montreal, Canada; J. W. Brown, Cleveland, Ohio; William Hand Browne, Jr., New York City; Charles E. Burgess, Madison, Wis.; Henry S. Carhart, Ann Arbor, Mich.; H. R. Carvelth, Niagara Falls, N. Y.; J. A. Capp, Schenectady, N. Y.; T. Parkinson Coffin, Schenectady, N. Y.; H. B. Cohn, New York City; Edward A. Colby, Newark, N. J.; C. L. Colwell, Cleveland, Ohio; Albert C. Colvin, N. Y.; A. M. Conney, Chester, Pa.; H. R. Connell, Schenectady, N. Y.; Elmer E. F. Creighton, Schenectady, N. Y.; S. Crider, Cleveland, Ohio; T. E. Crossman, New York City; Edward Durant, New York; Saul Dushman, Toronto, Canada; Thomas H. Fecey, Canandaigua, N. Y.; Colvin G. Fink, Schenectady, N. Y.; A. M. Fischer, Philadelphia, Pa.; C. M. Fitzgerald, New York City; Francis A. J. Fitzgerald, Niagara Falls, N. Y.; Richard Fleming, Lynn, Mass.; Charles C. Foster, Rochester, N. Y.; Richard H. Gaines, New York City; W. W. Gault, Schenectady, N. Y.; A. E. Gibbs, Wyandotte, Mich.; Geo. G. Grover, Ansonia, Conn.; Mr. and Mrs. C. A. Hansen, Schenectady, N. Y.; J. L. Hayden, Schenectady; Carl Hering, Philadelphia, Pa.; Henry D. Hibbard, Plainfield, N. J.; Miss R. Hosner, Schenectady; Henry Howard, Brookline, Mass.; Matthew Hunter, Schenectady; W. F. Hurlburt, Newark, N. J.; L. W. Hyman, Albany, N. Y.; Mois von Isakovics, Monticello, N. Y.; D. Forbes Keith, Toronto, Canada; Milton M. Kohn, New York City; S. J. Koskinen, New York City; Irving Langmuir, Schenectady, N. Y.; J. Kugler, Schenectady; Frank A. L. Lillien, Ithaca, Niagara Falls, N. Y.; A. T. Lincoln, Urbana, Ill.; C. F. Lindsay, Schenectady, N. Y.; Mr. and Mrs. A. B. Marvin, Jr., Schenectady, N. Y.; J. T. Matthew, New York City; Mr. and Mrs. John T. McElroy, Schenectady, N. Y.; J. McElroy, Albany, N. Y.; D. McIntosh, Montreal, Canada; E. P. McKee, Albany, N. Y.; Ralph McNeill, New York City; Max Meyer, New York City; Misses Helen and Mary Miller, Albany, N. Y.; Harlan S. Miner, Gloucester City, N. J.; R. B. Moore, Schenectady, N. Y.; Charles W. Norton, Schenectady, N. Y.; R. S. Noulton, Schenectady, N. Y.; R. H. Palmer, Schenectady, N. Y.; Charles L. Parsons, Durham, N. H.; Harrison E. Patten, Washington, D. C.; Harold C. Pease, Schenectady, N. Y.; Henry Pickler, Amper, N. J.; Henry Noel Potter, New York City; Louis C. Raeger, New York City; Miss Margaret Rand, Troy, N. Y.; A. G. Reeve, Niagara Falls, N. Y.; J. W. Richards, South Bethlehem, Pa.; Ralph C. Robinson, Schenectady; Mrs. Samuel Robinson, Boston, Mass.; E. F. Roemer, New York City; W. E. Ruder, Schenectady, N. Y.; Miss M. J. Rygles, Schenectady, N. Y.; L. B. Schleeder, Schenectady, N. Y.; G. P. Scholl, New York City; Clayton H. Sharp, New York City; A. W. Smith, Cleveland, Ohio; S. C. Smith, New York City; A. J. Super, Montreal, Canada; J. C. Sullivan, Schenectady, N. Y.; H. W. Sykes, Syracuse, N. Y.; Mr. and Mrs. Edward R. Taylor and Miss Edith Taylor, Penn Yan, N. Y.; John B. Taylor, Schenectady, N. Y.; M. deK. Thompson, Boston, Mass.; J. T. Toner, Niagara Falls, N. Y.; Willis G. Tucker, Albany, N. Y.; William Valentine, Lansingburgh; A. L. Voge, Zurich, Switzerland; Louis I. Waldman, Albany, N. Y.; Tracy D. Waring, Perth Amboy, N. J.; Oliver P. Watts, Madison, Wis.; Roger C. Wells, Schenectady, N. Y.; R. H. White, Rochester, N. Y.; Mr. and Mrs. J. A. Whitman, Boston, Mass.; W. H. Whitney, Schenectady, N. Y.; Leland M. Willey, Schenectady, N. Y.; Frank A. Wolf, Washington, D. C.; F. C. Zapf, Schenectady, N. Y.; C. Irving Zimmerman, Niagara Falls, N. Y.

Calcium Silicide for the Purification of Metals, Particularly Steel.

By HANS GOLDSCHMIDT, Ph.D.

Numerous metals and alloys have been used for a number of years for purifying liquid steel. Among these the best known are manganese, in the form of ferromanganese; silicon, employed in recent years chiefly as high-grade ferrosilicon; also alloys of manganese, silicon and iron. Aluminium has also been a well-known addition, for the reason that it possesses in extraordinary degree the ability to rid liquid steel of the last particles of oxygen or, to use a homely phrase, to "kill" the steel. In this application very small quantities, such as 0.05 per cent., have given satisfactory results.

In spite of its well deserved popularity, this purifying agent (the use of which is necessary in a great many cases) possesses two disadvantages which interfere with its general usefulness; the one might be called a positive, the other a negative property—"negative" in the sense that there is a desirable property which it ought to have, but does not have.

The "positive" quality consists in the fact that the aluminium oxide Al_2O_3 (which is formed during the deoxidation process) remains in appreciable quantities in the steel; in other words, it does not separate out completely into the slag. The cause of this lies in the high melting point of the oxide. It chills already at the temperature of the liquid steel, as the melting point of

Al_2O_3 , even with some impurities of other metals, is above $1800^\circ C$. On polished and etched steel sections these small particles of Al_2O_3 can be discovered by means of the microscope.

In this connection, it may be of interest to note that titanium also has the property of leaving traces in the steel. On sections of such steel, red crystals of titanium cyanonitride may be observed. This observation also proves that titanium (used in the form of ferrotitanium) has the property of binding nitrogen. The mechanical properties of the steel, however, are somewhat interfered with by these small non-metallic impurities.

What I call above the "negative quality" of aluminium is the fact that it is unable to bind any sulphur that may be present in the steel. It is just in this respect that calcium silicide shows to advantage as a purifier. It has the special property to reduce the last traces of sulphur, the elimination of which is often of the highest importance in the manufacture of special steels.

The difficulties of producing a steel with a maximum of 0.02 per cent. sulphur are well known. Specifications—particularly of the government—often call for that amount as a maximum. One can then take a steel with 0.04 to 0.06 per cent. sulphur, add the calcium silicide and thereby reduce the sulphur to the allowable proportion. In doing so, calcium sulphide is formed, while the silicon is mostly oxidized and combines with the oxides present to a highly liquid slag. This slag remains liquid quite as long as the steel and therefore finds it easy to rise to the surface and the impurities (such as are present with the aluminium) disappear as a result of the treatment with the calcium silicide.

Silicide of calcium represents, therefore, an entirely new and effective purifying agent, which is used exactly like aluminium.

The calcium silicide employed in practice contains about 30 per cent. calcium, the remainder being principally silicon. As impurities, a few percentages of iron are present. An important point in its application is that it is technically free from carbon. In appearance it resembles silicon, being coarsely crystalline, very brittle and remaining unaffected by the influence of the atmosphere. A definite formula for its use can, of course, not be given, being controlled by the peculiarities in the composition of the steel which is to be purified. A series of tests with analyses will quickly instruct the steel maker.

The introduction of this method was only begun during the first months of this year, after the subject had been studied for a long time. In Germany it has received considerable attention and large quantities of steel have already been refined by this process, while nearly all large steel works are now making tests with it.

A further field that promises much is the refining of nickel, copper or bronze castings with calcium silicide. Its mission is, of course, not to drive out the aluminium, but only to complete the series of purifying agents by enabling certain kinds of steel to be improved in a simple and quick manner.

Society of Chemical Industry.

At the meeting of the New York section of the Society of Chemical Industry, held on April 16, Dr. Roland Calberla, of the chemical department of Columbia University, gave an account of laboratory experiments on the production of ferrochrome in the electric furnace. Dr. Wm. J. Schieffelin then described an interesting process of making lithia from lepidolite; as a result of the drop in the price of lithia the process is, however, no longer in use. Prof. William Hallock, of Columbia University, finally presented an informal, but very interesting experimental lecture on "a new gas for illuminating, heating and power purposes," discussing the possibilities of Blau gas, which is now being introduced in this country, especially for train lighting.

¹Practical experience proves that ferrotitanium is not suitable for alloying if the titanium is present in a larger percentage than 20 to 25. Higher percentages resist alloying with liquid steel.

The Tank House and Copper Furnaces of the New Addition to the Raritan Copper Works

BY FRANK D. EASTERBROOKS.

Tank House.—This building, in which the copper bullion is electrolytically refined, is 149.5 ft. wide and 584 ft. long. The skeleton frame contains approximately 500 tons of steel and rests on heavy concrete foundation walls, while the 12-in. brick walls were built without pilasters, except on the ends under the crane runways, the steel frame carrying the main loads.

The building is divided into three bays running lengthwise of the building with two 10-ton three-motor Whiting cranes

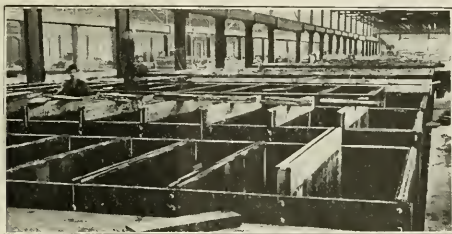


FIG. 1.—TANKS DURING CONSTRUCTION.

in each bay, which are equipped with a special device with fixed guides, for handling a tank full of anodes or cathodes at one time.

The following table contains data relating to these cranes:

		Horse-power of motor	Speed of motor	Travel of crane
	Make of motor	of motor	r.p.m.	ft. per min.
Trolley	Westinghouse	4	690	175
Bridge	"	26	640	350
Hoist	"	40	575	40

A clearance of 19 ft. 8 in. in the two outside bays and 31 ft. in the center bay between the floor and the bottom chord of

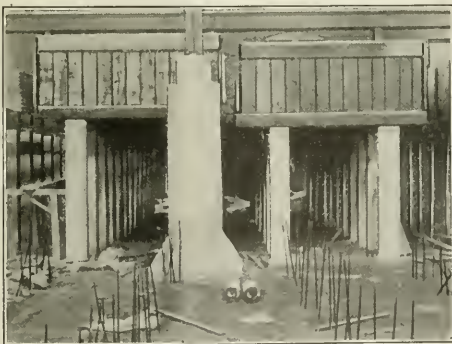


FIG. 2.—VIEW OF TANKS FROM BASEMENT.

the roof trusses, together with a great number of windows and the large monitor which runs the full length of the building, makes the tank room extremely well lighted and ventilated; in addition, a heating system installed by the New York Blower Company completely changes the air in the building every hour. The roof planking is covered with a 5-ply tar and gravel roof.

Basement.—Special attention was given to the construction of the basement. Arcaways were built entirely around the building, with numerous windows in the concrete foundation walls, and the whole inside was covered with two coats of whitewash, which gives a well-lighted interior requiring no artificial illumination.

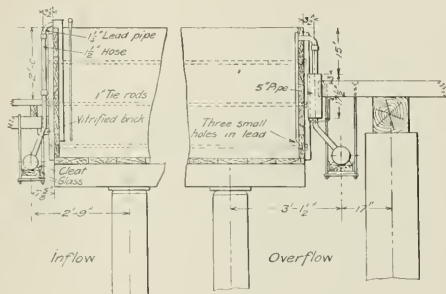


FIG. 3.—DETAILS OF CIRCULATION.

For the basement floor, it was decided that bricks laid on top of a concrete bed with the joints filled with pitch would be the most durable, provided a brick could be obtained which was unaffected by the sulphuric acid solution. To this end some 20 to 25 different makes of bricks were tested for a considerable length of time, with the result that the Berlin brick manufactured by the New York Brick & Paving Company, which was used, was found to be acid proof. The whole floor is drained toward three lead-lined sumps.

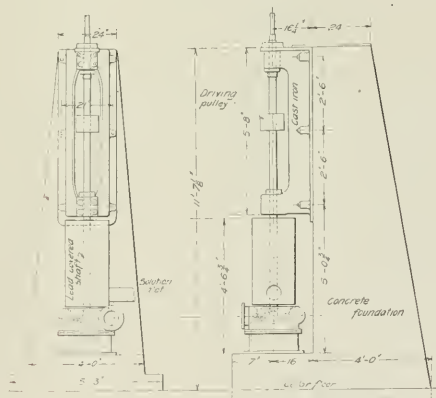


FIG. 4.—HARD LEAD CIRCULATING PUMP.

The light, airy cellar and the large head room, 9 ft. 9 in. between top of basement floor and top of main floor, are of great assistance in detecting quickly any leaks and runovers, while the acid-proof floor prevents loss from solution leaks or accidental spilling of slimes, losses from these two causes being greater even in well regulated plants than is generally supposed.

Three concrete tunnels connect the power house with the tank house basement. This building with its light basement, acid-proof floor and airy main floor, together with the ventilating and heating system, is, so far as the writer knows, the best adapted for the work of any yet built, and should

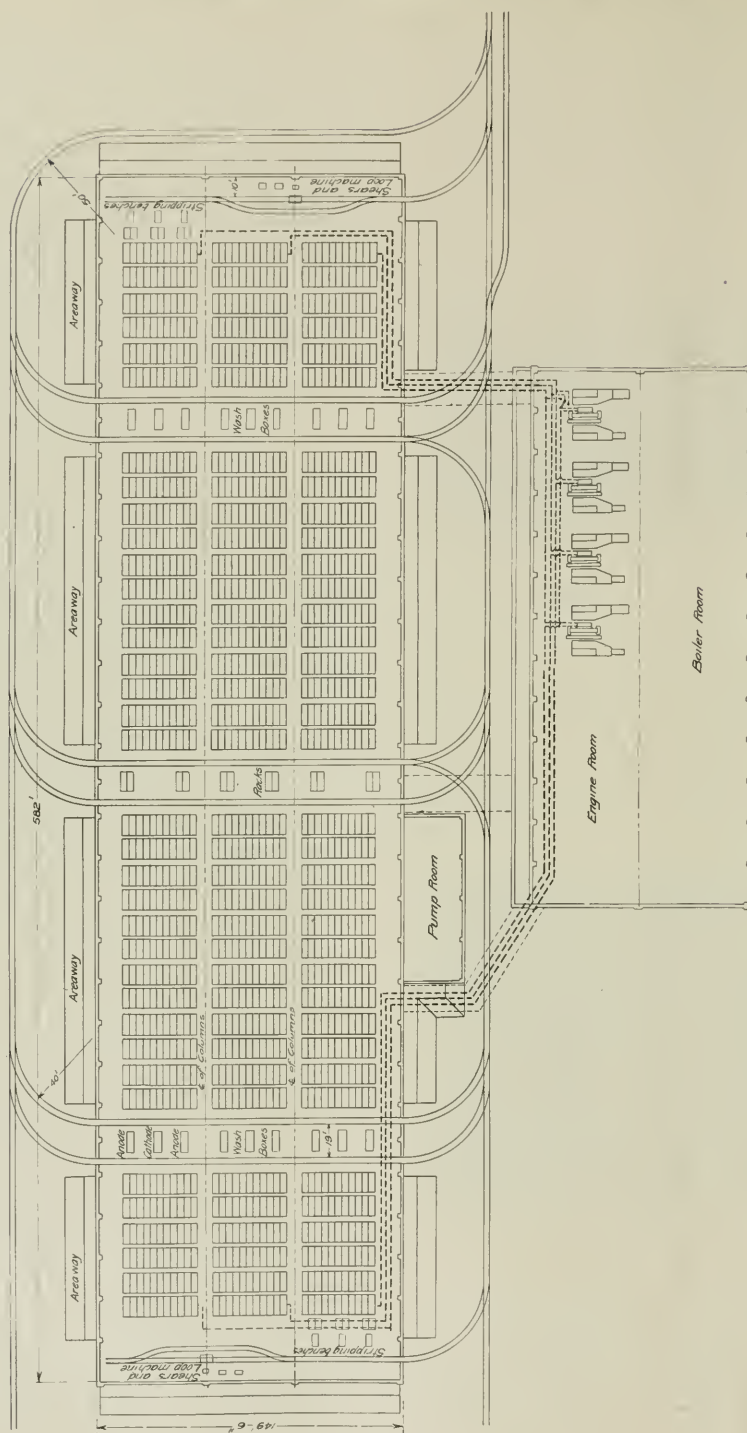


FIG. 5.—PLAN OF TANK HOUSE.

prove of some assistance to the operating department in that which is really the ultimate aim of all industrial establishments, the reduction of operating costs.

General Arrangement.—There are 1188 depositing tanks in the building, arranged in 108 nests of 11 cells each. Two nests of 11 cells each are placed together so as to circulate the electrolyte in cascade through two tanks. The tanks were

page 269) and the Walker arrangement amounted to between 450,000 and 500,000 lb. in favor of the latter.

A heavy glass plate 12 in. square, placed on top of the concrete piers which were constructed to support the tanks, serves to insulate them from the ground. See Fig. 5 for general arrangement of tank house and Fig. 6 for detail of tank construction.

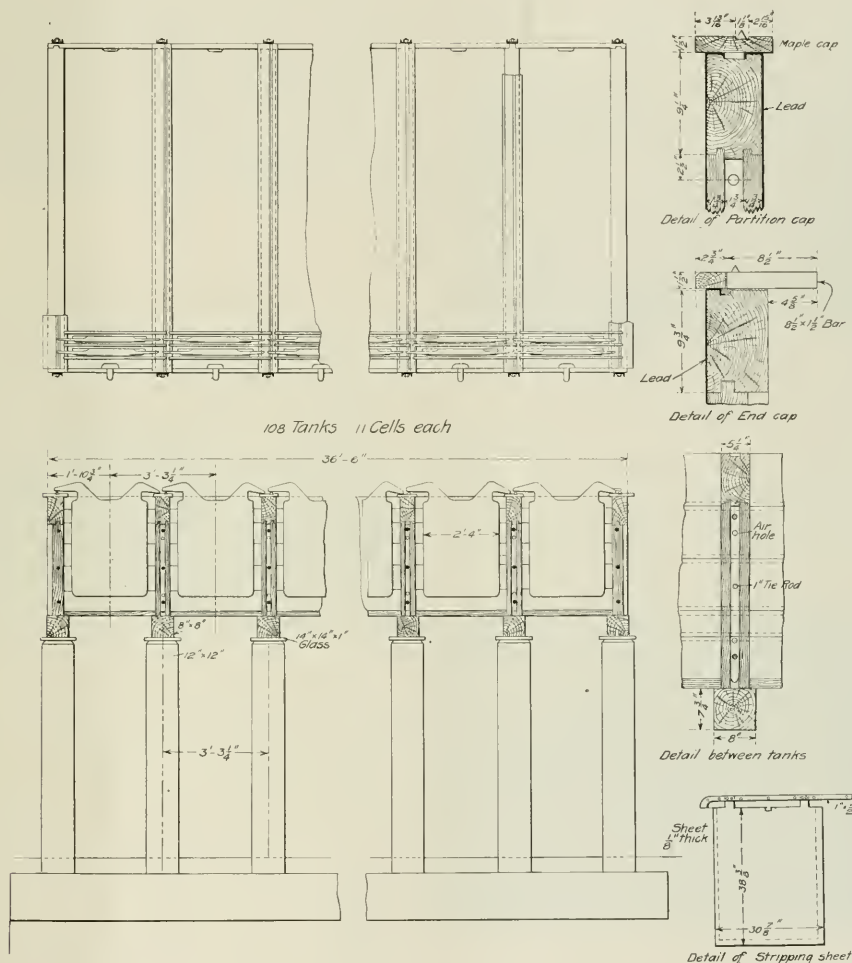


FIG. 6.—DETAILS OF TANK CONSTRUCTION.

constructed according to the Walker arrangement (U. S. Patent No. 687,800), which is now in general use at the electrolytic copper refining plants of the American Smelting & Refining Company, Maurer, N. J.; The U. S. Metals Refining Company, at Chrome, N. J., and The Mountain Copper Company at Martinez, California.

The large amount of current used requires for its economical transmission a busbar of large cross-sectional area. With the size adopted, 123½ sq. in., the difference in the amount of copper tied up in busbars and connections between the arrangement in use in the No. 1 tank house (for a description of which arrangement see Mineral Industry, Volume IX, 1901,

At diagonally opposite ends of the building are located the shears for trimming cathode loops, and the Morrow loop machine (U. S. Patent 600,498) for attaching copper loops to the cathode starting sheets.

Special tanks for rinsing the electrolyte from the cathodes, after being removed from the depositing tanks and before loading on cars, are located in the main aisles, as are also the tanks for scrubbing the slimes from the scrap anodes, before returning them to the anode furnaces.

Tank Details.—Each tank contains 24 anodes and 25 cathodes, spaced on 4½ in. centers. The anodes are 28 in. wide by 36 in. long, while the cathodes are about 30 in. wide

by 37 in. long, giving an active cathode service per tank of approximately 369.5 sq. ft. With a current of 7500 amperes this gives a current density of 20 amperes per square foot.

The tank room is divided into three circuits running lengthwise of the building, one in each bay. Each circuit of 396

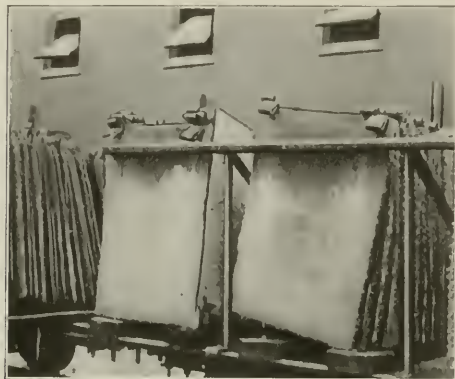


FIG. 7.—METHOD OF LOADING CATHODES.

tanks forms a load for one of the electrolytic generators in the power house.

The main conductor bars have a cross sectional area of 12.75 sq. in., but busbars at each end of the nests of tanks are proportioned so as to reduce the amount of copper held permanently in plant, only that portion carrying the full current between two nests of tanks having the full area. That surface of the bars forming contacts with the anodes and cathodes is of triangular shape, making a knife edge contact



FIG. 8.—LINING TANKS WITH LEAD.

which is more easily kept clean than a flat bar. The tanks are lined with 6-lb. lead containing 4 per cent antimony.

Circulation of Electrolyte.—The general direction of the electrolytic circuits is lengthwise of the tank house, while the circulation of the electrolyte is crosswise. For circulation purposes the tank house is divided into 6 units of 198 tanks each. The rate of circulation is about four gallons of solution per tank per minute. The solution enters at the bottom of each tank and overflows, as shown in Fig. 3, overflowing in greater part from the top, while a smaller portion of the heavier solutions is taken from the bottom of each tank.

The hard-lead centrifugal pumps for circulating the electrolyte are located in a building on the south side of the tank

room, and are of a special design which was worked out at this plant. See Fig. 4 for the general arrangement of the pump, the chief feature of which is that there are no stuffing boxes or wearing parts in contact with the solution, the shaft bearings being placed above the level of the inflowing solution. This pump has solved the problem of an entirely satisfactory method for circulating a hot sulphuric acid solution, and while the efficiency is good, reliability and low operating costs were the main features considered.

For maintaining the copper contents of the electrolyte at a fixed quantity, the copper anodes in a regular depositing tank are replaced by lead ones. The simple expedient of placing a heavy oil on top of the solution in these tanks, with precautions to prevent its running off, prevents the gases from contaminating the air.

When slimes are to be removed from the tanks the circulation is stopped and the current shunted from two nests of tanks. The slimes, after being screened and flushed through launders to a sump, are pumped to the slime-receiving tanks

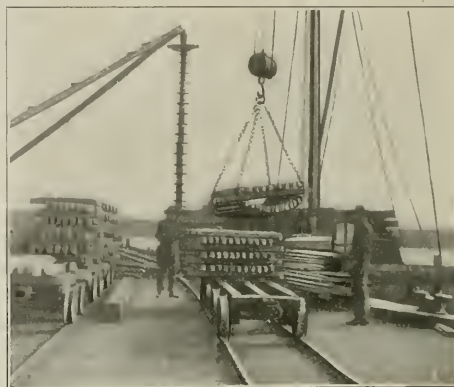


FIG. 9.—LOADING WIRE BARS FOR SHIPMENT.

in the silver refinery by means of a small hard-lead centrifugal pump of the same design as the circulating pumps.

Starting Sheet Tanks—The "stripping" tanks are located at diagonally opposite ends of the tank room. The heavy rolled copper plate on which the starting sheet is formed has the rod from which it is hung riveted to it. (See Fig. 6). A small V-shaped groove cut in around the outside edges of the sheet does away with the necessity of using wooden strips in order to obtain satisfactory starting sheets (McCoy Patent No. 684,291, and Elliot and Kitchner Patent No. 683,263).

A thin coating of rack grease rubbed over the stripping plate serves to prevent the deposited sheet from firmly adhering to the plate. The stripping of these starting sheets, which is done on benches located in the end aisles next to the tanks, is a laborious operation, and of course any increase in the size of the cathode sheets renders this operation more difficult.

The production of good, sound starting sheets is a fundamental in tank-house operation. The sheets as stripped from the plates are thrown onto small cars, rolled across the building to the machines, where two copper loops are riveted on, and, after being beaten out smooth, are hung in the tanks from round copper rods flattened at one end.

The cathodes are removed from the tanks by the crane, a tank full at a time, and after rinsing in warm water to remove the copper sulphate solution, are unloaded in an upright position directly onto specially constructed cars (see Fig. 7) without any handling except that necessary to remove the rods from the loops.

The anodes (the size of which was increased over that in use in No. 1 tank house) are brought into the building on steel cars and placed in steel racks in the same relative position that they will occupy in the tanks. They are put in the tanks by the crane, a tankful at a time. As the labor cost in the

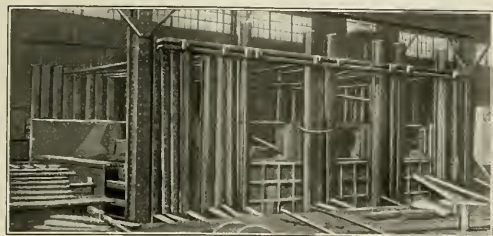


FIG. 10.—VIEW OF WIRE BAR FURNACE.

tank room depends on the number rather than the weight of the electrodes handled, any increase in the weight and size of the individual pieces will effect a reduction in the unit labor cost per ton of copper refined.

The cathodes remain in the tanks 14 days before being removed; the anodes 28 days, when they are taken out, washed clean of slimes and sent to the anode furnaces to be recast into anodes. In actual practice this scrap amounts to about 13 per cent of the total weight of copper treated, or expressed in another form, 13 per cent of all the copper refined is held in process of treatment for a further period of several days in order to be case into anodes, sampled and weighed. It is then placed in the depositing tanks for another period of 28 days.

The above also holds true for the gold and silver contents of the copper, 13 per cent of the total values treated being delayed for a corresponding period of time before they are transferred to the silver refinery.

In operating the tank house, a working schedule is first made out. As the anodes remain in the tanks 28 days, each tank must be cleaned once in that time. The day's work is divided equally among the three circuits, care being taken also that the tanks cleaned shall be divided equally among the different circulations, on account of the storage required for the solution removed from the tanks.

In the following table is given the approximate amount of refined copper required to construct and operate the tank house. The copper wire necessary to connect up the various motors, or the Cooper Hewitt mercury-vapor lamps with which the tank house is lighted by night, are not included.

Copper cathode rods.....	186,000 lb.
Stripping rods.....	122,000 "
Lead anode rods.....	3,000 "
Busbars, connections, etc.....	170,000 "
Leads, etc.....	100,000 "
Total	581,000 lb.

It may be of interest to note that the amount of copper held in the tanks at any one time in process of treatment amounts to between 11,000,000 and 12,000,000 lb., while the amount held in solution in the electrolyte is approximately 240,000 lbs. The amount of lead used in constructing the tank house was about as follows:

Lining tanks, etc.....	1,050,000 lb.
Pipe for solution, overflows, etc.....	180,000 "
Pump room, lead anodes, etc.....	140,000 "
Total	1,370,000 lb.

In the following table are given some of the principal features of the No. 1 and No. 2 tank houses.

	No. 1 Tank House	No. 2 Tank House
Total number of depositing tanks.....	1,600	1,188
Anodes per tank.....	21	24
Cathodes per tank.....	21	25
Size of anodes.....	2' x 3'	2' 4" x 3'
Size of cathodes.....	2' x 3'	2' 6" x 3' 1"
Sq. ft. cathode surface per tank.....	252	369.5
Current in amperes.....	5,000	7,500
Current density in amperes per sq. ft. cathode surface	19.8	20.
Number of circulations.....	4	6
Cross-sectional area of busbars in sq. in.	5	1234
Number of tanks in cascade.....	5	2
Number of circuits.....	5	3
Anodes, number days corroding.....	35	28
Supports for tanks.....	timber	concrete

Anode Furnaces.—No new furnaces were built for casting anodes from pig copper, as the material refined in the No. 2 tank house is received already cast in that shape. Two of the original anode furnaces were, however, enlarged, increasing their capacity to 200,000 lb. daily. The anodes are cast in iron molds on a mechanical conveyor, from which they are loaded on to skeleton frame steel cars of heavy construction by means of an air hoist. The molds in which the copper is cast are made in two pieces clamped together according to the Anticell patent (U. S. Patent No. 867,694), which greatly increases the life of the molds.

The coal used in the wire bar and anode furnaces is brought from the coal trestle in electric cars. An elevator which was furnished by the Albro-Clemm Company and located just outside the No. 1 furnace building raises these cars to tracks which run the length of both furnace buildings and which are supported by the roof trusses. Hoppers located so that the coal is delivered in front of the fire-box door receive the coal from these cars.

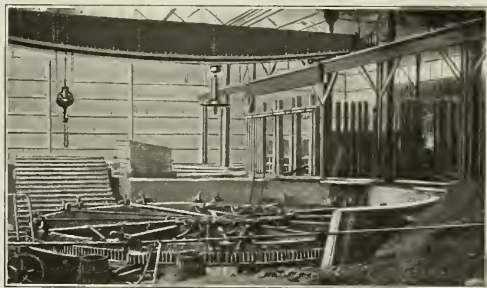


FIG. 11.—WIRE BAR CASTING APPARATUS.

Wire Bar Furnaces.—For casting the cathodes into wire bars and ingots, two new furnaces, each of 150 tons capacity, were constructed in the No. 2 furnace building. These furnaces have a hearth 33 ft. 6 in. by 16 ft. 9 in., with an area of 470 sq. ft. The fire box is 8 ft. by 10 ft., giving a ratio of 1 to 6 between the area of the fire box and that of the hearth. The foundation and piers are entirely of concrete construction.

In order to reduce the time of charging such a large quantity of cathodes, doors were constructed on each side of the furnace, two on one and three on the other side, thus permitting of charging crews working from both sides of the furnace at the same time. The roof of the furnace was constructed of 13½-in. brick. The bottom is made up of 18 in. of sand on 9 in. of silica brick, resting on the 134-in. iron plates, which are carried by the concrete piers. The conker

plates and the iron castings over the charging doors are water cooled. The gases pass through a short flue to the 6 ft. brick-lined iron flue 100 ft. in height, which is located just outside the building, the intention being to install waste heat boilers at a later date, taking the gases from the flue close to the furnace.

For casting the copper from these two furnaces two casting machines of a new design (Clark patent, U. S. No. 818,076) were constructed. These machines consist essentially of two parts, the wheel proper on which the copper molds are carried, and the conveyor which raises the bars from the bosh. Fig. 11 shows a general view of the wheel and conveyor during construction.

The wheel is made up of a series of I-beam arms fastened at the circumference to a heavy iron casting, the outside of which forms the rack by means of which the wheel is revolved. The diameter of the wheel is 36 ft. The double copper molds are attached parallel with the I-beam arms, one on each side, so that the stream of copper as it is poured from the ladle flows lengthwise of the mold, four bars being cast at one time.

An automatic arrangement allows the bars to be dumped from the molds when directly over the bosh, while a self-righting device returns the mold to an upright position just before reaching the ladle.

The copper when tapped from the furnace flows through a launder, 6 ft. 6 in. long, to a large ladle and thence into the molds. This ladle is raised and lowered by a hydraulic lift, the operator controlling with one hand, by means of a three-way valve, the tilting of the ladle, while with the other hand the rotation of the wheel is regulated by means of the regular controller. The bars, after being dumped, are taken from the bosh by a conveyor which is constructed of steel channel irons carried on an endless chain of link work. This conveyor is driven by a separate motor.

When casting copper, water is circulated through the bosh by means of a 14-in. centrifugal pump driven by a Ball & Wood horizontal tandem compound engine located in the No. 1 power house. In order to reduce the amount of water used, which is an important feature where such large quantities of copper are being cast, a reservoir was constructed where it could be pumped back and cooled by spraying through air before being returned to the boshes.

Metallurgical Calculations.

By J. W. RICHARDS,
Professor in Metallurgy in Lehigh University.

The Metallurgy of Zinc—III.

The condensation of zinc from the state of vapor follows the same laws as regulate the condensing of all gases. If it is by itself in a cooler space, it condenses by contact with the walls as finely divided zinc dust (blue powder) if the walls are cold, as liquid zinc if the walls are hot, and it keeps on condensing until the tension of the remaining vapor is equal to the maximum tension of zinc vapor at the temperature of the condensing vessel. This condition having been reached, no more will condense until the condenser is cooled. At any temperature, therefore an amount of zinc remains uncondensed corresponding to the maximum vapor tension of zinc at that temperature.

If other indifferent gases are present, the zinc vapor sustains only part of the atmospheric pressure, or pressure on the whole mixture, so that condensation cannot begin until a lower temperature is reached; that is, a temperature at which the maximum vapor tension of the zinc equals its partial vapor tension in the gas mixture. At this point condensation begins and continues as the temperature falls, the gas mixture always being saturated with zinc vapor. The phenomenon is precisely similar to the production of rain by the cooling of air containing moisture.

As to what the vapor tension of zinc is, the data are scanty.

The boiling point under atmospheric pressure is 930° C., where its vapor tension is 760 m.m. of mercury column. According to Barus, the maximum tension increases 6.67 m.m. for each 1° C. increase of temperature. This is a difficult determination, but corresponds satisfactorily with the calculated increase from analogy to water and mercury.

Water, boiling at 100° C. (273 absolute), varies 1° in boiling point for 27.20 m.m. variation in vapor tension; mercury, boiling at 357° C. (630° absolute) varies 1° in boiling point for 12.66 m.m. variation in vapor tension. The ratio of the two variations is seen to be practically the inverse ratio of the two boiling points.

$$\frac{630}{273} = 2.3 \quad \frac{27.20}{12.66} = 2.2$$

If we compare mercury with zinc, with the two boiling points 357° and 930° (630° and 1203° absolute), and the observed variations in vapor tension at the normal boiling point of 12.66 m.m. and 6.67 m.m. per 1° rise in boiling temperature, the two ratios are

$$\frac{1203}{630} = 1.91 \quad \frac{12.66}{6.67} = 1.90$$

This coincidence justifies us completely in assuming that the vapor tension curve of zinc may be calculated directly from that of mercury, by assigning for any given vapor tension an absolute temperature to the zinc vapor of 1.91 times that of mercury vapor. For cadmium we may use the similar ratio of the normal boiling points in absolute degrees:

$$\frac{273}{273 + 357} = \frac{1053}{630} = 1.67$$

and thus calculate the cadmium curve from the mercury curve.

From incipient vaporization to ebullition in a vacuum.

Tension of vapor m.m. of Hg.	Mercury C°.	Cadmium C°.	Zinc C°.
0.0002	0	183	248
0.0005	10	200	267
0.0013	20	216	286
0.0020	30	233	305
0.0063	40	250	324
0.013	50	267	344
0.026	60	283	363
0.050	70	300	382
0.093	80	317	401
0.165	90	333	420
0.285	100	350	439
0.478	110	367	458
0.779	120	383	477
1.24	130	400	496
1.93	140	417	516
2.93	150	433	535
4.38	160	450	554
6.41	170	467	573
9.23	180	483	592

Before proceeding further, we would remark that cadmium melts at 320° and zinc at 410°: that both can, therefore, show vaporizing phenomena nearly 150° below their melting points. At 9 m.m. tension, 180° C., mercury begins to show the phenomena of ebullition, and we would, therefore, expect cadmium to "simmer" at 483° and zinc at 592°. Neither of these observations have as yet been experimentally investigated, so far as the author knows.

From ebullition in vacuum to normal boiling point.

Tension of vapor m.m. of Hg.	Mercury C°.	Cadmium C°.	Zinc C°.
9.23	180	483	592
14.84	190	500	611
19.90	200	517	630
26.35	210	533	649
34.70	220	550	668

45.35	230	567	687
58.82	240	584	706
75.75	250	600	726
96.73	260	617	745
123.	270	634	764
155.	280	650	783
195.	290	667	802
242.	300	681	821
300.	310	700	840
369.	320	717	859
451.	330	734	878
548.	340	750	897
663.	350	767	915
760.	357	780	930

The above table contains the more important data for the actual condensation of zinc, cadmium and mercury vapors in practice. Thus, if a mixture of zinc or cadmium vapor with an equal volume of indifferent gas goes into a condenser, the partial pressure of the metallic vapor being in this case only half an atmosphere, or 380 m.m., no metal will commence to condense until the temperature of the gases is reduced to 862° for zinc and 720° for cadmium. If mercury vapor from a roaster is mixed with 19 times its volume of other gas, so that it only forms 5 per cent of the mixture, its partial tension will be only 5 per cent of 760 m.m. = 38 m.m., and no mercury will commence to condense until the temperature of the gas mixture is reduced to 224°. These temperatures are exactly analogous to the phenomenon of the dew point of moist air, the temperature at which rain forms.

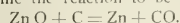
From normal boiling point to high pressures.

Tension of vapor atmospheres.	Mercury C°.	Cadmium C°.	Zinc C°.
1.0	357	780	930
2.1	400	851	1012
4.25	450	934	1107
8.	500	1018	1203
13.8	550	1101	1298
22.3	600	1185	1394
34.0	650	1268	1489
50.	700	1352	1585
72.	750	1435	1680
102.	800	1519	1776
137.5	850	1602	1871
162.	880	1652	1928

The latter table may have several special applications. If zinc, for instance, were placed in a closed electric furnace filled with indifferent gas and capable of supporting 100 atmospheres pressure, zinc could be kept in the liquid state up to some 1700° C., and its alloying with other metals greatly facilitated. In the making of brass, for instance, much zinc is lost by volatilization at the melting point of the copper used, yet a pressure on the furnace of four atmospheres would entirely prevent loss of zinc at the melting point of copper. Induction electric furnaces could easily be run inside a pressure vessel at this temperature, and the pressure be relieved gradually as the temperature of the melted alloy was reduced. To keep zinc from boiling, or to keep it in the liquid state, at 1300°, not a high temperature, would require a pressure of nearly 14 atmospheres to prevent it from boiling *ad libitum*.

Problem 134.

Roasted zinc sulphide ore, consisting practically of pure ZnO, is reduced by carbon, and the reduction gases passed into a condenser. Assume the reaction to be



Required:

(1) The temperature at which zinc commences to condense from the above gas mixture.

(2) The proportion of the zinc condensed out for each 1° reduction of temperature below this "dew point."

(3) The proportion of the zinc escaping uncondensed, if the gas escapes from the condenser at 600° C.

(4) How would these data be affected, if the reduction was taking place at Denver, 1500 meters above sea-level, barometer 560 m.m.?

Solution:

(1) Since zinc vapor has been shown to have a specific gravity of 32.5 referred to hydrogen gas at the same temperature and pressure, and the molecular weight of hydrogen gas, formula H_2 , is 2, the molecular weight of zinc vapor must be $2 \times 32.5 = 65$. This coincides with the atomic weight of zinc, and therefore zinc vapor is monatomic and the symbol of its molecule is Zn. The gas mixture in the above equation contains, therefore, one molecule each of its two constituents, and, therefore, each gas supports half the atmospheric pressure. This is ordinarily expressed by saying that the gas is half one constituent and half the other, meaning that if the two gases were separated and each measured under the prevailing normal pressure, the volume of each would be half the volume of the gas mixture. The statement that each supports half the normal pressure is the more scientific and logical, for in a gas mixture each gas certainly possesses the volume of the mixture, but under only a fraction of the pressure on the mixture, said fraction being identical with the fraction of the volume of the whole which it would constitute, if measured separately under the pressure supported by the mixture.

Consulting the table, we find zinc vapor to have a pressure of 380 m.m. at 862°. This would, therefore, be the dew point, at which the zinc would commence to condense.

(2) At this condensing temperature, a difference of 19° in the temperature corresponds to 82 m.m. difference in the maximum vapor tension, and, therefore, in this gas mixture at this temperature, a reduction of 1° in its temperature will reduce the tension of the zinc vapor $82 \div 19 = 4.3$, or practically 4 m.m. This will result in the condensation of $\frac{4}{380}$ ths. of the zinc, because its tension was 380 and was reduced to 376, and, therefore, $\frac{376}{380}$ ths. of it remained uncondensed. The proportion condensed for the reduction of 1° in temperature is, therefore, a trifle over 1 per cent.

(3) Leaving the condenser at 600°, the tension of the zinc vapor escaping would be, from the table, 11.6 m.m. The tension of the CO gas would, therefore, be $760 - 11.6 = 748.4$ m.m. For every cubic meter of mixed gases, at 862°, containing a cubic meter of zinc vapor at that temperature and 380 m.m. pressure, there will escape a fraction of a cubic meter of mixed gas at 600°, containing zinc vapor at 11.6 m.m. pressure. The fractional volume can be calculated from the tension on the CO.

1 m³ CO at 862° and 380 m.m. pressure, reduced to 600° and 748.4 m.m. pressure, becomes

$$1 \times \frac{600 + 273}{862 + 273} \times \frac{380}{748.4} = 0.381 \text{ m}^3.$$

This is, then, the actual volume of gas mixture escaping, for each actual 1 m³ of gas mixture in the condenser at the "dew point," 862°.

The uncondensed zinc vapor is, therefore, 0.381 m³ at 600° and 11.6 m.m. tension. This would be, at 862° and 380 m.m. tension

$$0.381 \times \frac{862 + 273}{600 + 273} \times \frac{11.6}{380} = 0.015 \text{ m}^3.$$

There, therefore, escaped uncondensed

$$\frac{0.015}{1.000} = 0.015 = 1.5 \text{ per cent of the zinc.} \quad (3)$$

A quicker solution, not so easy to understand, however, is

$$\frac{11.6}{748.4} = 0.015 = 1.5 \text{ per cent uncondensed.}$$

(4) If the operation takes place at such elevation above sea-level that the barometer stands normally at 560 m.m., then the partial pressure of the zinc vapor, in above case would be 280

m.m. instead of 380 m.m., and the "dew point" or temperature at which condensation commences would be 835° instead of 802°, as under previous conditions.

At this temperature, a difference of 1° in the temperature corresponds to a difference of 3 m.m. in the tension of the zinc vapor, producing therefore a condensation of the zinc present, per 1° fall of temperature, of $3 \div 280 = 0.011 = 1.1$ per cent, instead of 1.2 per cent.

If the temperature of the escaping gases is 600°, with the saturated zinc vapor at 11.8 m.m. tension and the carbonous oxide, CO, at $560 - 11.8 = 548.2$ m.m., the proportion of the original quantity of zinc escaping uncondensed is $11.8 \div 548.2 = 0.022 = 2.2$ per cent, instead of 1.5 per cent.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

Institution of Mining and Metallurgy.

Metallurgy of Gold.—MR. ALFRED JAMES, in his presidential address, read at the annual meeting on April 2, presented a concise sketch of the advances made in the treatment of gold-bearing material during the last twenty years. He said that in the earlier portion of this period British or American technical literature contained hardly any noteworthy reference to problems of gold mining or milling. The rough-and-ready method of doing things then had now given place to scientific accuracy; and one result of the consequent progress has been to place on a sound commercial basis the winning of gold from ores already developed or opened out, and investments in certain established gold mines were found in the troublous times of a year or two ago to have depreciated less in value than our own government consols. This great advance was rendered possible by the superior training and attainments of the engineers in charge, as well as by the foresight and enterprise of the great firms and corporations which controlled them. Small 10-stamp propositions have developed to huge undertakings running 200 stamps or more; managers were required of wider and more scientific training than many of our mining-foremen friends of twenty years ago had; and, the requisite number of highly trained men not being available in this country, a demand arose for assistance from our American confrères.

It is impossible to survey the history of the past twenty years without bearing witness to the extraordinary effect of the keenness, energy and ability of our transatlantic brethren, so many of whom we are proud to number among our members. The old sources could supply the type of man required, but not in sufficient numbers, and the best among the Old World men have not merely held their ground, but have actually gained by their being pitted against the methods and practice of the new school. But in the training of our new men we are again indebted to, among others, our American brethren who have pointed out how our methods of technical training differ from theirs; and thus it has come to pass that the graduate of 1908 is a much more practical and practicable product than was his predecessor of 1888. His holiday practical schools and post-graduate courses have inspired him with a keenness to get at the bottom of things first-hand; and he can now adjust and apply his theory to practical operations in a way attainable previously only after much, oftentimes, painful experience. The contrast of the twenty years is also seen in the methods employed. Then, electric winches, motors, pumps and signals were practically unknown, and the use of electrical appliances underground had not been generally developed. Improvements effected in hoisting had rendered possible the raising of upwards of 2,000 tons per day through one shaft, and underground sanitation has been considerably advanced.

But it is in the treatment of gold ores that, possibly the greatest evidence is found of the progress of the last twenty years. In 1888 the number of gold mines not employing assay-

ers was considerable, and even one gold metallurgist on the local staff was, indeed, a rarity, but the new metallurgy of gold ores and the technical skill required have changed all this, and the adviser is now no longer merely troubled about the best methods of treating an ore, but also, and even more so, as to the methods most suitable to the skill and intelligence of the local technical staff. Filter presses were at first reported failures, yet greater experience caused the condemned failures to be hailed as great successes.

The following improvements in treatment methods are worthy of notice: The sorting of waste rock from reef matter to be milled; the use of separate crushing stations with high-capacity crushers; the general adoption of mechanical transport for the ore; the provision of storage bins of great capacity; the provision of special water supply, usually with its acidity neutralized, for the mill; the use of heavy stamps; the use of long, unbroken plates for mill amalgamation and of shaking plates for forced amalgamation after tube mills; the adoption of re-grinding appliances, such as pans and tube-mills, although the economy of tube mills is doubtful; the provision of automatic weighing and sampling devices; the introduction of the cyanide process for treating sands and slimes, which has now been generally adopted, even at chlorination works; the use of improved mechanical roasting furnaces making refractory ores (sulphide, arsenical, telluride and even antimonial) amenable to the cyanide or chlorination processes; and the provision of tailing wheels or other suitable means for elevating pulp.

The adoption of the cyanide process has brought about such improvements as separation of sands and slimes; the direct filling of sand-vats without preliminary settlement; the use of spitzkasten and conical vats resulting in great saving of water and the abolition of tailing dams; the use of belt conveyors for residues; and the use of the decantation filter press and other methods for recovery of gold from slimes.

As the period covered by these remarks is coincident with the existence of the cyanide process, it is interesting to add that practically all the gold mines in South Africa—the Robinson and a few others excepted—pay their dividends from their recoveries by cyanide; and this observation applies with still greater force to the gold mines of the Waikato (New Zealand) and Kalgoorlie (West Australia) districts. Indeed, the cyanide process seems to have taken a firm hold of the gold mines of the world with the notable exceptions of the Gympie and Mount Morgan districts, of Queensland. A 6-dwt. rock is now regarded as profitable, and sand with less than $1\frac{1}{2}$ dwt. per ton as worth large installations. Contrast this with the 5 dwt. to 20 dwt. tailings of 1888.

The one district of Witwatersrand now produces more gold than the total output of the world in 1888, which itself was little more than one-quarter of the present figure—22,000,000 for 1888 and 82,000,000 for 1907.

The address then refers to the valuable results of the international exchange of ideas, together with the aid of the technical press, and concludes by suggesting standardization of terms, practice and mining accounts.

Metallurgical Research at the National Physical Laboratory During 1907.

Thermometry at High Temperatures.—For the Féry type of radiation pyrometer with mirror, provision was made for simultaneous testing of ten instruments and a standard on a "black-body" furnace, the temperature of which is measured by a thermocouple and a potentiometer. With this particular type of radiation pyrometer no window may be interposed at the mouth of the furnace on account of the great proportion of the radiant energy employed lying in the red and infra-red parts of the spectrum; and the size of the mirror—3 in.—necessitates an aperture of considerable diameter, and, consequently, a large furnace. The furnace used was of the ordinary type with platinum fill winding, and was capable of giving temperatures up to 1,400° C. To minimize the effect of convection currents

the mouth was inclined downward at an angle of about 30 deg. with the horizontal. It was found that the cooling effect of the current of air in the mouth of the furnace produced a very steep temperature gradient in the porcelain tube, causing the fairly rapid destruction of both tube and foil.

A furnace was then built with the tube placed vertically and surrounded by a thick lagging of magnesia in a firebrick casing. This was found to take less power, and to give a very uniform temperature throughout and better insulation in the thermocouple circuit. The pyrometers were mounted vertically on a turntable, by the rotation of which they were brought successively under the furnace mouth. Experiments have also been made on a new type of "hot strip" as a secondary standard.

A description will shortly be published of an improved carbon-tube furnace designed to obviate the alterations in specific resistance and mechanical properties due to graphitization, as well as other defects, which has given very good results, and is adapted for uniform heating of fairly large objects to about 2,500° C. It has been employed for the study of the melting and boiling points of a number of metals and oxides. Some of these melt over a range rather than at a definite point; others, which are cheap and easily obtained, seem suitable for use as standard high-temperature melting points.

For very high temperature work in "cascade furnaces" (see our vol. III, p. 273), with solid electrolytic conductors, tubes of refractory oxides—both pure and mixed—have been made up to considerable diameters; and difficulties encountered in early attempts to squirt such tubes have been overcome. Substantial progress is anticipated during 1908 in the construction of larger cascade furnaces of the type used two years ago in the work on the melting point of platinum, and it is hoped that by the use of this type of furnace an attempt may be made, in conjunction with the photometric department, to realize the Vielle standard of light as defined by the radiation from 1 sq. cm. of platinum at its solidifying point.

In connection with platinum thermometry, recalibration of the platinum-thermometer bridge, referred to in the report for 1907, shows that the changes in the coils have been very small, while a restandardization of all the British Association standard platinum-thermometers demonstrates that no certain changes have occurred in their constants.

The standard thermocouples, too, exhibit no noteworthy variation. Many high-range mercury thermometers have been tested during the past year, and a considerable general improvement in the quality of these is noted, but low-range mercury thermometers are less satisfactory. The properties of fused silica at high temperatures are being thoroughly investigated, and the test will include an examination of the effect of prolonged heating on its mechanical properties and a determination of its coefficient of expansion up to its softening point.

The Programme of Research Work at the National Physical Laboratory for 1908.

The Engineering Department proposes to undertake, among other work, the investigation of the resistance of materials to impact, in connection with which the adoption of standard tests is contemplated. The experiments begun in 1907 on the resistance of surfaces and solids in a current of air at high velocities will be continued with the view of designing and constructing full-sized apparatus for such work. Experiments on the resistance of materials to abrasion will be further conducted, with steel rails in particular, under conditions which will more nearly approximate to actual working conditions than was the case last year. The investigation of the elastic limits of materials under alternating stress will be carried on by testing specimens which have been subjected to many reversals of a stress less than the limiting stress, and by trying to vary the elastic limits by overstrain and recovery.

The Department of Metallurgy and Metallurgical Chemistry will proceed further with the investigation of the alloys of copper and aluminium with, firstly, manganese and later with nickel and zinc; and with these ternary systems a complete

series of tensile, impact, alternating stress, hardness and corrosion tests will be made.

The Seawater Corrosion Tests on alloys at Portsmouth will be continued, and a series of similar tests will be begun at Malta.

It is hoped that the proposed work on *Cooling Curve Methods* may result in the setting up of a satisfactory form of autographic apparatus for obtaining recalescence curves of metals and alloys.

With the apparatus that has been set up for focussing by aid of monochromatic blue light, it is anticipated that the work on *Photomicrography of Metals by Ultra-violet Light* will yield satisfactory results at very high magnifications.

The *Eutectic Alloys Research* will be carried on. The lead-tin series will be satisfactorily explored first, and a detailed study of the constitution of the silver-copper group will follow. At present the observed facts in the lead-tin series are not easily reconciled with the view that the constituents of an eutectic alloy are necessarily similar in constitution as well as in composition to the corresponding "free" constituents. This point will receive especial attention in studying other series. Differences between various members of the same series of alloys in respect of the amount of contraction they undergo during solidification will also be studied—in the first place with the lead-tin series. The location of the maximum or minimum of contraction on freezing will also be of interest. At present it is proposed to confine this work to alloys having comparatively low melting points.

Iron and Steel and General Metallurgical Analysis.—The accuracy of various methods of analysis is to be thoroughly examined and checked by comparative analyses of standard samples and by comparison with other methods, and new methods are to be tried.

Market Prices During April.

During April tin has undergone some sharp jerks, rising to £145 on the 3d, and dropping to £142 on the 7th. Thence a fairly steady rise to £144 per ton.

Lead has shown a steady downward tendency from £14 10 0 at the beginning of the month to £13 12 6 at the time of writing.

Copper, Standard, dropped fairly steadily from £59 to £58 without excessive alterations.

In the iron market, hematite pig (Scotch) is at 61 -, slightly down. For Cleveland pig there is little demand; a slow rise to 52/- took place. Clyde pig is quoted at 64 6.

Chemicals register the following prices:

	£	s.	d.
Ammonia sulphate, f.o.b. Liverpool, per ton.....	12	5	0
Copper sulphate, per ton.....	24	0	0
Caustic soda, 77 per cent. white, per ton.....	11	2	6
Bleaching powder, 35 per cent., per ton.....	4	10	0
Carbolic acid, 97/99 per cent., per gal.....	1	0	
Cresote oil, good ordinary liquid, per gal.....		2½	
Shellac, Standard T. N., orange spots, per cwt.....	4	15	0
Antimony, Star Regulus, per ton.....	£33	to 35	0 0

International Congress of the Refrigerating Industries.

The first International Congress of the Refrigerating Industries will be held in Paris, France, from Sept. 17 to 23, 1908. A very elaborate program has been arranged and the Trans actions will be printed in book form.

There are six different sections, devoted to low temperatures and their general effects; refrigerating appliances; the application of refrigeration to food; the application of refrigeration to other industries; the application of refrigeration in commerce and transport; legislation. We will print a fuller program in our next issue.

The officers of the American Committee are: Mr. Homer McDaniel, president; Mr. John E. Starr, vice-president; Mr. John S. Field, treasurer, and Mr. J. F. Nickerson, 315 Dearborn Street, Chicago, secretary.

RECENT METALLURGICAL PATENTS.

Iron and Steel.

Refining and Purifying.—An important saving of time and gain in yield in steel manufacture are claimed to be the advantages of the preparatory process of Henry D. Hibbard (885,248, April 21, 1908). The object is to utilize the calorific power of metalloids in crude iron in the reduction of iron from its oxide, so as to furnish a purified and refined iron to the open-hearth furnace or converter. The treatment of the crude iron may result in the following three effects: (1) refining, i. e., elimination of silicon and manganese; (2) purifying, i. e., elimination also of phosphorus and sulphur; (3) also partial decarbonization. The treatment is carried out in a vessel charged with a quantity of molten crude iron and oxide of iron. The crude iron must contain sufficient metalloids to give, by their oxidation, enough heat to reduce a sufficient amount of oxide or iron, to supply the necessary oxygen and maintain the charge in a molten condition during the treatment. By a special method of agitation of the charge which will be described below, the reaction between the metalloids of the crude iron and the oxide of iron will be started and will burn the metalloids which will generate sufficient heat to keep the mixture molten, as well as to reduce the chemical equivalent of iron from its oxide and to form the slag, and this without the addition of fuel or heat to the vessel beyond that added in the two ingredients. The quantity of ore or other oxide of iron added is proportioned to the amount of crude iron used and the amount of decarbonization desired in the product. Only enough oxide of iron may be added to the charge to burn the silicon and manganese, and in some cases the phosphorus, or more may be added to burn a part of the carbon. Enough carbon is kept in to lower the fusion point of the iron to the proper degree in order to keep the refined metal liquid at the temperature of the process. The apparatus in which the process is carried out is a vessel with two pockets, with a dividing partition between them. The charge introduced into the vessel is mixed by oscillating the vessel back and forth upon its axis so that the molten charge is poured over the dividing partition wholly or in a large part at each oscillation, the lighter oxide on the top going first and the heavier metal then passing through it. This repeated pouring of the heavier metal through the lighter oxide is an important feature of the process. The vessel is oscillated back and forth so as to rapidly pass the metal through the oxide of iron. Some thermochemical calculations are given to illustrate the principle.

Alloy Steels.—Hitherto the temperatures of the bath have ordinarily not been carried beyond 2500 or 3000° F. when melting metals to form steel. James Churchward (884,009, April 7) points out that such temperatures are not sufficiently high in the manufacture of alloy steels to "bring the alloying metals into a proper condition for entry and interchange." The evident reason is the very high melting point of most of the elements introduced into alloy steels. Each of the steel alloys takes a different period of time to enter and interchange and these periods vary from 30 seconds to 30 minutes dependent on how refractory the alloying metal is. By bringing the temperature of the metal bath to about 3100° F. or 3600° F. and holding it at this temperature for a period of from 15 to 60 minutes the metal becomes in a more receptive state to interchange and enter into union with the alloying metals than it does at a temperature below about 3100° F. The application of this method to the manufacture of nickel-chromium-manganese steel is described.

A special nickel-chromium-tungsten steel is patented by R. H. Illingsworth (882,112, March 17, 1908, assigned to Crucible Steel Company of America). Steel of approximately 0.60 per cent. carbon and containing substantially 2.50 per cent. nickel, 1.25 per cent. of chromium and 1 per cent. of tungsten shows, after hardening in oil in the well-known manner, a high elastic

limit and high tensile strength combined with high elongation.

Puddling Furnace.—In our vol. IV, p. 353, we described in detail Mr. James P. Roe's mechanical oscillating puddling furnace. A recent patent granted to him (881,342, March 10, 1908) relates to the construction of the hearth. The bottom of the hearth is inclined downwardly from each end to a middle part on an obtuse angle. An arched bow-shaped roof is provided high at the center and ends and low at the intervening parts.

Nodulizing.—The treatment of pulverulent iron ores in a rotary gas furnace to ball them together for subsequent treatment in the blast furnace, is the subject of a patent of H. Dicke (886,683, May 5, 1908). It is pointed out that dusty or pulverulent ores should be fused either without any additions at all or at least with such small quantities of added matter, as will enable the fusion to take place only at a temperature of 1000° C., in order that the agglomerated ore shall withstand any temperature less than 1000° C. In order to effect this, it is necessary to work with a pointed flame, and, above all, the gas must be supplied under an excess of pressure. This excess of pressure of the gas, which may be effected by collecting the gas in a gas holder, is believed to be absolutely necessary for regulating the shape and the oxidizing capacity of the flame.

Sintering.—E. B. Clark (887,379, May 12, 1908) proposes to make fine ores, flue dust, pyrites, residuc, etc., available for use in the basic open-hearth process. The fines are treated in a long inclined rotary kiln, which they leave in a semi-plastic condition to the compressing rolls, which compress the agglomerated ore into the form of blocks or lumps of suitable size to be used instead of ore in the open-hearth process.

Aluminium.

Aluminium Alloy.—W. Grossmann (886,579, May 5, 1908, assigned to Fried. Krupp, A. G.) patents an aluminium alloy which has several valuable properties over the known aluminium alloys of small specific gravity, such as alloys of aluminium and zinc. The new alloy consists of about 87 per cent of aluminium, 8 per cent of copper and 5 per cent of tin. The content of copper in the alloy may vary between 7 and 8.5 per cent, and the content of tin may vary between 4.5 and 5.5 per cent. The alloy can be easily cast. The castings are completely homogeneous and have relatively high rigidity.

Gold.

Extraction of Metallic Values.—D. R. Robertson, of Denver, Col., (886,886, May 5, 1908), patents a process, the application of which to the extraction of gold and copper from ore is described as follows: A ton of crude ore, reduced to about 80 mesh, is mixed with 2 gal. of aqua regia and enough water is added to reduce the mass to the consistency of soft mud. This mass is agitated and steam is applied to it for a period of about two hours gradually bringing it to the boiling point. Enough cold water is then added to equal 30 per cent of the weight of the mass. The mixture is drained through a filter into a precipitating tank, containing about 20 lb. of old scrap iron or iron rust and maintained at a temperature from 65 to 70° F. The metallic values are precipitated on the iron and may be removed by scaling off. The process is said to be applicable to high- or low-grade ores. With softer ores which yield quickly to the treatment, the expense is comparatively less.

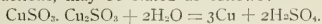
Cyanide Plant.—H. L. Templar, of Cleveland, Transvaal (886,802, May 5), patents the following method of handling the ore from the time it leaves the stamps or amalgamation plates until it is deposited in vats or otherwise prepared for treatment by cyaniding. The pulp coming from the battery or from the amalgamated plates is passed by a launder to a mechanical classifier (for instance, a Wilfley table set) to separate the battery pulp into three parts, the first consisting of substantially dry concentrates, the second a pulp of sands and water, and the third slimes mixed with the bulk of the crushing water. The slimes and water are passed off into a

chute and are carried away by a launder for disposal in any desired manner. The sands pulp is delivered from the classifier into a chute from which it falls onto a traveling web screen. The water associated with the sands and also any slimes therewith pass through the screen into a discharge launder thereunder and may conveniently be led thence into the slimes launder. The sands pass over the screen in a substantially dry state and drop onto a conveyer by which they are carried to the sands lixiviation vats. The concentrates being delivered dry by the separator, are taken directly, for instance, by a belt to separate lixiviation vats, but in cases where it is not feasible to deliver the concentrates dry, the water is first separated from them by a moving screen, as in the case of the sands. In many instances the concentrates, instead of being treated immediately with solvent, are required to be reground in tube mills, grinding pans or other similar apparatus. In such instances the concentrate lixiviation vats are dispensed with and the belt carries the concentrates—dry as before—to the tube mill; it being found to be advantageous to feed the mill with substantially dry material and to feed by separate means the exact quantity of water necessary for grinding, since the amount of water necessary to carry the material as pulp is largely in excess of that required for grinding. Several modifications of the arrangement are described.

Slimes Treatment.—C. E. D. Usher, of Johannesburg, Transvaal, (886,900, May 5, 1908), treats slimes by percolating the solvent solution or wash water upwards through the slimes which are maintained in a uniform and practically constant state of diffusion throughout the suspending liquid, the rate of flow and manner of distribution of the solvent or wash water being such as to maintain the slimes in suspension and yet allow the solvent or wash water to collect in a clear state above the slimes, whence it may be withdrawn as desired. The process is carried out in a cylindrical vat, the slimes and the solution being introduced through two concentric hollow tubes, in the center of the vat. The lower end of the slime tube is open, while the lower end of the solution tube connects with several side arms with apertures through which the solution is sent upwards.

Copper.

Wet Process.—L. Jumau (883,962, April 7, 1908), leaches copper ores with an ammoniacal solution and then treats the solution with sulphurous acid, precipitating copper in form of cuproso-cupric sulphite. The precipitate is then heated under pressure in the presence of an aqueous solution, for instance, the solution from which the precipitate has been thrown down. The final operation of the last step, omitting certain intermediate reactions, may be stated as follows:



The copper precipitate thus obtained is absolutely pure and free from sulphite or oxide of copper. The above-described reaction is found to begin between the temperatures of 140°C . and 160°C ., and to become nearly completed at 170°C . The process can, therefore, be conveniently carried out in any usual lead-lined digester of copper or iron.

Yellow Brass.—R. Stribeck (887,540, May 12, 1908) remarks that all species of latten (yellow brass), which are actually on the market and which are called susceptible of being rolled and cast into molds, affect more or less considerable brittleness when exposed to or worked at temperatures between 300 and 550°C ., so that they cannot be used for numerous purposes. Such brittleness is caused by a certain percentage of lead or oxides, or both, which cannot be avoided in the usual methods of production of the alloys. The present inventor tries to avoid this "hot-brittleness" of yellow brass by the addition of a certain quantity of phosphorus, the percentage of the latter being provided in order to produce an alloy in which 0.03 to 0.10 parts of phosphorus are contained per 100 parts of total weight of the alloy ready for being worked or otherwise used. Latten toughened according to this method is said to be available for numer-

ous applications in which it is exposed to high temperatures. As an example of such cases in which common latten-alloys are unsuitable may be cited pipings conducting superheated steam, etc.

Lead.

Treatment of Galena.—A. Francis (882,193, March 17, 1908) melts galena with a suitable flux and then introduces the molten matte into a furnace containing molten lead, so that the molten lead sulphide floats on top of the bath of molten lead. By blowing air through the bath the lead is oxidized and combines with the sulphide, thereby converting the sulphide into metallic lead. For every two parts of lead oxidized three parts of metallic lead are produced.

SYNOPSIS OF PERIODICAL LITERATURE.

Electrochemistry.

Electrolytic Alkali and Bleach Industry.—In the *Lond. Electrician*, April 24, J. B. C. Kershaw gives a review of this industry in 1907. He estimates the total number of works as 36, with a total power available of 67,000 hp, equivalent to an output of 134,000 tons of 70 per cent caustic soda and 280,000 tons of 35 per cent bleaching powder per year. The (British) Castner-Kellner Alkali Company have paid 12 per cent dividend during the last year, the success being attributed to the scrap of old plant, notably the substitution of a Mond gas plant and Koerting gas engine for an old steam plant at one of their works. Part of the chlorine produced is used by the company for making zinc chloride by the Swinburne-Ashcroft process. A new Italian plant has been started since The Società Electrochimica del Cofiro has completed a plant for producing caustic soda and chlorine by a modification of the Kellner cell and process. The caustic soda is sold in the form of a solution concentrated to 38 deg. Baume. The company uses common salt from Sicilian mines as raw material, and the plant has a working capacity of 20 tons a day.

Metallic Mirror for Search Lights.—Ever since the introduction of search lights for battleships, attempts have been made from time to time to substitute metallic mirrors in place of glass ones, which are unsatisfactory, due to the fact of their being so readily broken by concussion when firing the guns, and that the silvering at the back of the mirrors is very liable to blister and leave the surface of the glass. The difficulty of making true parabolic mirrors has been overcome by the Cowper-Coles electrolytic process which, as described in *Lond. Elec. Eng'ing*, April 9, briefly consists of depositing by chemical means on the convex side of a glass former or mould a thin silver film and then spinning the former in an electrolytic cell charged with copper anodes and a copper electrolyte, so as to deposit the copper on the silver surface, the process being continued until the silver film has received a sufficient thickness of copper to give the desired rigidity to the parabolic mirror. The glass mould and the electro-deposit are then removed from the depositing cell and placed in a vessel containing cold water, the temperature of which is gradually raised until the expansion of the copper is sufficient to cause the metallic mirror to leave the glass former. The silver-faced mirror thus produced has as highly polished a surface as the glass, and is finally subjected to an after-treatment to prevent the silver from tarnishing and then mounted in a metallic ring (which fits in the projector case) provided with knife edges, which firmly grip the edge of the mirror without distorting it. A large number of mirrors made by this process have been supplied to the British government, some of which were sent out to the South African War. Mr. Cowper-Coles is now introducing a new metallic mirror which is only partially made by electro-deposition. The mirror has a surface composed of alternate bands or rings of gold and white reflecting surfaces which, it is claimed, give a more penetrating beam of light both at night and in foggy weather. Objects on which such a beam of light

is thrown stand out in greater relief than in a light thrown from a silver white metal mirror, and the intensity of the light is so great that it is impossible to aim accurately at the projector. Another advantage claimed for the new mirrors is that they are not fractured by concussion, and even when penetrated by bullets the area of distortion is very small.

Electric Laboratory Furnace.—A new electric laboratory furnace is described by L. Clerc and A. Minet in a recent issue of *Comptes Rendus* and in the *London Electrician* of April 24. One of the authors noticed that the length of an arc playing in a cavity at the center of a refractory mass, such as lime or magnesia, reached several centimeters for such electric constants as 40 amperes and 50 volts. When these experiments were repeated the two following facts were observed: (1) For a constant e.m.f. from 50 to 60 volts, the arc could be given any length on the condition that the transverse section of the cavity was varied in proportion to a certain power (greater than unity) of the arc length, and at the same time the current was varied in proportion to another power (less than unity) of this section. The values of these powers correspond to a practically constant arc temperature. (2) When the arc is burning properly a crucible of some refractory conducting substance, such as carbon, or non-conducting material, such as

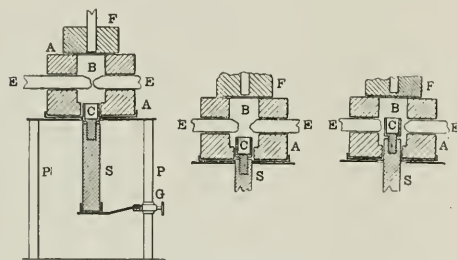


FIG. 1, 2, 3.—ELECTRIC FURNACE.

lime or magnesia, can be introduced into the arc without extinguishing or altering the electrical constants. An electric furnace designed on these lines is shown in Figs. 1, 2 and 3, these being three different positions of the crucible. The furnace consists of two principal parts (A and F) and is made of a refractory substance, such as lime or magnesia. The part A is bored out cylindrically along a vertical axis, two chambers being thus formed. One of these (B) is the furnace, whose dimensions are 3 cm in diameter and 6 cm high. The other, whose diameter is 2 cm is a continuation of the first, and through it the crucible (C), whose capacity is about 2 cubic cm, can be introduced. The crucible is held up by a support (S), made of a non-conducting substance, such as lime or magnesia, having an arm terminated by a slider (G), which is provided with a set screw, so that it can be moved along one of the supports (P) of the apparatus. The crucible, therefore, may be raised and occupy a position in the furnace (B) in accordance to the distance apart of the electrodes (EE), which are made of carbon. By employing 1 kw to 2 kw experiments can be made in this furnace at all temperatures, from a dark red, when the crucible and electrodes are in the position shown in Fig. 1, to the temperature of the arc (Fig. 3). The capacity of the crucible is sufficient in all cases to contain from 2 to 40 grams of material, according to its density. With currents from 30 to 40 amperes the arc can be maintained in spite of the consumption of the carbons. It is, however, possible to separate the electrodes to their extreme limit without the arc going out, and if the electrode, having first been taken out, is reintroduced quickly into the apparatus the arc is struck when the carbons are still apart. Current leakage due to the walls of the apparatus when at a temperature equal to that of melting magnesia need not be taken into account.

Metallurgy.

Phosphor-Copper.—A recent Faraday Society paper of Prof. A. K. Huntington and Dr. C. H. Desch deals with "the planimetric analysis of alloys and the structure of phosphor-copper." The authors discuss the conditions under which it is possible to estimate the relative proportions of the constituent metals of an alloy by means of a planimetric measurement of the areas of the solid phases exposed in a polished and etched micro-section. Details of the method are given, and its accuracy is shown by a series of measurements of analyzed alloys. The method has been most fully studied in the case of phosphor-copper, of which a number of photo-micrographs were shown. In the case of alloys containing less than the eutectic proportion of phosphorus, however, the area of the copper crystals is found to be considerably greater than that calculated from the composition determined by analysis. The origin of the discrepancies was traced to the segregation of the eutectic, the copper crystals which separate at first drawing to themselves a portion of the copper of the surrounding eutectic. The crystals are, therefore, surrounded by a belt of copper phosphide. By measuring the area of this belt and thence calculating the amount of segregated copper, a correction may be applied to the area of the crystals, and a very satisfactory agreement with the analytical results is thus obtained. In the discussion it was stated by Dr. Desch that the method could not be of quite general applicability, it being useless, for instance, in cases of homogeneous alloys. It was also necessary for the alloy to be in a state of physical equilibrium. Prof. Huntington added that the method would probably be usefully extended to the case of phosphor-tin alloys.

Interaction of Aluminium Powder and Carbon.—This subject is discussed in a recent Faraday Society paper by Frank E. Weston and H. Russell Ellis. Very little work has been done on the combination of Al and C at temperatures lower than that of the electric furnace. F. Fichter (*Zeitsch. Anorg. Chem.*, 1907, 54), using a mixture of soot and aluminium, produced an impure aluminium nitride; Matignon (*C. R.*, cxlv., No. 17, 1907), using a mixture of lampblack and aluminium, obtained a product, on heating in a Perrot furnace, which yielded a gas with water consisting of 96.36 per cent CH₄ and 3.36 per cent H₂. The authors have shown that the Al powder and carbon can be made to react at temperatures much below that of the electric furnace. Mixtures of Al powder and carbon, wood charcoal, sugar carbon and graphite have been prepared, in which reaction takes place in starting with a fuse of Mg powder and BaO₂, as in Goldschmidt's reaction; other mixtures have been made which only react when heated at temperatures varying from 400° C. to 1000° C. In all cases the products of reaction were found to be aluminium carbide (9.12 per cent to 65.91 per cent), aluminium nitride (3.07 per cent to 42.16 per cent), alumina (11.97 per cent to 55.4 per cent), aluminium and carbon. The carbide produced is most probably that described by Moissan as Al₄C₃, since the gas obtained on treating the product of reaction with either water or hydrochloric acid was found to consist of CH₄ and H₂, the latter coming from (1) the action of HCl in unaltered Al, (2) action of NH₃ on Al, the NH₃ being formed by the action of water on the aluminium nitride. The authors are of opinion that the chief cause of the reaction is to be found in the initial oxidation of the carbon, by atmospheric (and occluded) oxygen, to CO and CO₂, the heat of this reaction causing the oxidation of some of the Al to Al₂O₃, and the heat of this reaction causing the combination of the Al with carbon and atmospheric (and occluded) N₂. This view is supported by the fact that very little action took place in a mixture of Al and wood charcoal when heated to bright redness, *in vacuo*, in a steel tube, while the same mixture reacted energetically when heated in an open basin to just visible redness. In the discussion which followed, Dr. F. M. Perkin did not agree with the authors' view as to the cause of the reaction. There was no evidence that at 1100° CO could be reduced. Possibly the reaction was started by superficial oxidation of the

aluminium. C. Weiss referred to the aluminium carbides found at the bottom of the furnaces in which aluminium is made. As a rule, these carbides were entirely enclosed in a coating of alumina. H. R. Ellis gave some further particulars regarding the nitride produced, probably by the action of nitrogen at a high temperature on the aluminium carbide. As crude aluminium carbide can be made by heating clay and carbon in the electric furnace, this method might be as economical a one for the fixation of atmospheric nitrogen as the combination of calcium carbide and nitrogen to form cyanamide. Prof. A. K. Huntington suggested that perhaps the author's reaction was a triple one, brought about by the presence of a gas (CO_2 or CO) between two solids which would not react alone. The gas, unlike the carbon, might be able to permeate the film of oxide surrounding the aluminium, getting at the actual metal, and so start the reaction.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Low Carbon Ferro-Alloys.—E. F. Price, 886,858, May 5, 1908. Application filed Sept. 24, 1907. Assigned to Electro Metallurgical Company.

In the first step of the process a high-carbon ferro-alloy is produced by smelting a mixture of the ore of the alloying metal, an excess of carbon and a source of iron in an ordinary electric furnace with a carbon lining and with carbon electrodes. In the second step the carbon is removed from the ferro-alloy in an electric induction furnace at a high temperature by passing air through the molten alloy. The oxygen of the air burns the carbon while only an unappreciable loss of the alloyed metal by oxidation is encountered. At the high temperature employed the affinity of oxygen for carbon is greater than for the alloyed metal. (This is the reverse of the conditions in the Bessemer process.)

Cupro-Titanium.—A. J. Rossi, 12,764, March 17, 1908. Application filed May 23, 1902. Assigned to Titanium Alloy Manufacturing Company.

Aluminium ingots are charged into a bath of molten copper in an electric furnace and titanic acid is added in moderately coarse grains. The aluminium reduces the titanic acid and by the heat of this reaction, together with the electric heat, a molten copper-titanium alloy is produced with a slag of aluminium oxide. The first three claims refer to the process of manufacture, while the last two claims refer to the product. The fourth claim reads as follows: "As a new article of manufacture a compound or alloy containing an important quantity of copper, say, not less than 10 per cent of the mass, and titanium in industrially important proportions; that is to say, not less than 5 per cent of the mass."

Calcium-Carbide Furnace—E. F. Price, 886,856, May 5, 1908. Application filed Nov. 14, 1905.

The furnace has an open bottom beneath which is a movable receptacle which receives the molten product and is shifted to withdraw its contents from the product remaining in the furnace. A series of separate receptacles is employed, each serving in turn as the hearth or crucible of the furnace.

Manufacture of Refractory Articles of Magnesia, Etc.—C. F. Burgess, 884,463, April 14, 1908. Application filed May 31, 1906.

Fig. 1 shows the apparatus used for making magnesia crucibles. The vessels 1 of carbon contain a charge 2 of pure magnesia, within which are centrally disposed conductors 3 of carbon or graphite of such a shape as to conform to the interior of the vessel to be produced. These graphite conductors act as resistors. As shown in the illustration, they are inserted between fixed graphite blocks 6. The surfaces of the magnesia article next to the resistor 3 become sufficiently smooth and

regular, but difficulty was found in producing also smooth outer surfaces of the article. This difficulty is overcome by inserting a layer 7 of paper. By this simple means the portions of magnesia outside of 7 are readily separable at the surface 7 so that the contour of the magnesia crucible conforms to the original position of the layer 7.

Graphite-Amorphous Carbon Electrode.—E. F. Price and F. J. Tone, 887,123, May 12, 1908. Application filed Jan. 8, 1906.

Artificial graphite produced in the electric furnace is ground and mixed with a suitable hydrocarbon capable of being converted into a permanent binder. The mixture is then molded and baked at a temperature sufficient to decompose the hydrocarbon and drive off the volatile constituents leaving the residual carbon, which serves as a binder for the graphite. In order to produce electrodes with a lower heat conductivity than graphite and a higher electric conductivity than amorphous carbon, a portion of the graphite in the mixture is replaced by ordinary amorphous carbon. According to the proportions used the thermal and electric conductivity may be adjusted. The resulting electrodes are dense, strong and can be easily machined.

Fused Peroxides.—G. F. Brindley, 884,563, April 14, 1908. Application filed March 13, 1906. Assigned to Roessler & Hasslacher Chemical Company.

The object is to fuse materials of a corrosive nature without decomposing the same and destroying the containing vessels. The process is especially adapted for fusing alkali peroxides. The material is fused by means of an alternating current passed through it between electrodes in such a way that the current density is low in the material adjacent to the electrodes and high within the material to be fused, while a layer of non-fused material is formed and maintained on the inner walls of the containing vessel between the walls and the electrodes.

Artificial Mica.—F. J. Machalske, 885,934, April 28, 1908. Application filed March 21, 1907.

The materials of which mica consists (except the caustic alkalis) are melted in an electric furnace of the induction type in the proper proportions and to the molten mass the caustic alkalis are then added. The mass is then discharged and cooled slowly in an atmosphere charged with moisture. The water entering into the constitution of the artificial mica product is derived from the alkali metal hydrate and from the moisture of the atmosphere.

Electrolytic Furnaces.

Lead from Sulphide Ores.—E. F. Kern, 885,761, April 28, 1908. Application filed Sept. 1, 1906.

If lead sulphide ore, which is a conductor of electricity, is made the anode in a suitable fused electrolyte, which has a melting point below that of the ore, the lead and associate metals

of the ore may be deposited at, or in, the cathode, while the sulphur with which the metals are combined, is liberated from the bath, provided the temperature be above the boiling point of sulphur, which is 445°C . Frequently the natural galena is too fine; it is then melted with a suitable flux and the fused matte is cast into suitable blocks or cylinders to be used as anodes. As electrolyte a bath containing lead chloride is preferred. It has considerable dissolving power for lead sulphide, so that the bath is nearly or quite saturated with lead sulphide, giving an electrolyte which is fluid at 500°C . Other salts may be mixed with the lead chloride. The electrolysis is similar with different suitable electrolytes, the main difference resulting from the different temperatures which depend on the melting point

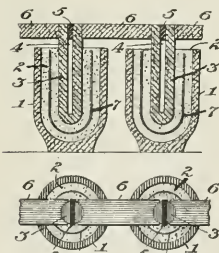


FIG. 1.—MAGNESIA FUSING.

of the bath. It is necessary that the melting point of the bath be below that of the sulphide ore so that the anodes remain solid. A bath liquid at about 500° C. is advantageous. The ampere-hour efficiency varies from 88 per cent to 94 per cent, the e.m.f. usually being about 2.5 volts with an anode current density of about 500 amperes per square foot. With a current density of about 1200 amperes per square foot, the e.m.f. varies from 4.5 to 6.0 volts. In either case, the distance from anode to cathode was from 1½ to 3 in. The lead which is reduced at the cathode is malleable, and free from sulphur, at least for all practical purposes, and the sulphur liberated at the anode is free from chlorine and sulphur chlorides. The zinc occurring in the lead ore is also recovered since it accumulates in the electrolyte.

Metallic Calcium.—E. F. Price and W. S. Horry, 886,857, May 5, 1908. Application filed Dec. 29, 1906.

A molten bath of calcium chloride or fluoride, preferably with additions of the corresponding salts of strontium and ammonium to lower the melting point, is electrolyzed with a composite anode of calcium carbide and a binder, any suitable cathode, for example, one of iron, being employed to receive the electro-deposited calcium. The anode gradually dissolves, the contained calcium recombining with the halogen ion to replenish the bath, while the carbon may float to the surface and be burned by the atmospheric oxygen. It is preferred, however, to dissolve calcium oxide in the electrolyte, in which case the oxygen ion is liberated at and combines with the carbon of the anode, correspondingly decreasing the consumption of electric energy, while the calcium ion of the oxide is deposited at the cathode simultaneously with that from the haloid salt.

Electrolytic Processes.

Nickel from Silicious Ores.—A. Chalas, 887,735, May 12, 1908. Application filed Sept. 6, 1907.

The object is to recover nickel from nickel-iron silicate ores, free from copper, such as are found in New Caledonia. In the first stage of the process the ore is reduced at a high temperature in an electric furnace to produce ferro-nickel, which is cast into convenient shape for anodes. These anodes are used in an aqueous solution of nickel-ammonium sulphate with nickel sheet cathodes. Pure nickel is deposited on the cathode, while nickel and iron are dissolved on the anode as double ammonium sulphate. During electrolysis, this solution is continuously circulated from the cell through a filter containing a body of precipitated nickelic hydroxide, which reacts upon the dissolved ferrous salt with production of nickel sulphate and precipitation of ferric hydroxide. The solution thus freed from iron and containing an additional amount of nickel equivalent to the removed iron, is continuously returned to the cell.

The nickelic hydroxide used for the precipitation is electrolytically produced from ferro-nickel anodes in an auxiliary cell with an aqueous solution of sodium chloride and sheet cathodes of nickel. As electrolysis proceeds, nickel and iron are dissolved from the anodes as chlorides, while a sodium hydroxide solution is produced at the cathode. These two solutions, when mixed, react with the production of nickalous and ferrous hydroxides, which precipitate, and sodium chloride, which dissolves and regenerates the electrolyte. The brine, carrying the precipitates in suspension, is circulated through a filter-press, which retains the hydroxides, the clear solution returning to the cell. When the filter-press has been filled with the precipitated hydroxides, their peroxidation is effected by circulating through the mass an aqueous solution of an alkali-metal hypochlorite, produced, for example, by the electrolysis of a cold dilute solution of sodium chloride. The nickalous and ferrous hydroxides are thus readily peroxidized and the hypochlorite is reconverted into sodium chloride, which is re-electrolyzed.

Diaphragm.—H. Hirtz, 885,098, April 28, 1908. Application filed Oct. 3, 1905.

A textile diaphragm of asbestos cloth is dipped into a solu-

tion of alkali ferrocyanide or ferricyanide and then into a solution of copper sulphate. In this way an additional diaphragm is precipitated within the asbestos cloth. When the diaphragm is to be used for an electrolytic cell wherein a solution of a metallic salt that forms an insoluble double cyanide is to be electrolyzed, it is preferable to use a solution of this salt as one of those with which the cloth is to be impregnated and a simple manner of doing this is to saturate the cloth first with a concentrated solution of alkali ferrocyanid or ferricyanide and then either before or after it has dried to place it in position in the solution in the electrolytic cell, whereupon the desired deposition occurs while the cloth is in place.

Nickel and Copper from Matte.—J. M. Neil, 882,075, March 17, 1908. Application filed June 3, 1907.

Copper-nickel matte is roasted in a revolving or reverberatory furnace in the presence of carbon and air in order to expel any sulphur and arsenic. The temperature is then raised in order to melt the metals. Part of the molten alloy is cast into slabs, used afterward as anodes, and the remainder is run into water and thereby disintegrated; it is then treated with sulphuric acid in a dissolving tower, to produce a concentrated sulphate solution. This is used as electrolyte between the slabs, mentioned above, as anodes and thin copper sheets as cathodes. Copper is deposited on the cathodes and an equivalent amount of copper and nickel is dissolved from the anodes. Electrolysis is continued until the electrolyte contains nickel sulphate and a small percentage of copper sulphate. This solution is treated with a sulphide, either in form of sulphuretted hydrogen or in form of a soluble sulphide, until the copper, iron, zinc, etc., are precipitated as sulphides. The nickel sulphate solution is filtered and treated with a solution of calcium chloride or barium chloride, etc., resulting in the formation of nickel chloride and the precipitation of calcium (or barium) sulphate. The nickel chloride solution is then subjected to electrolysis, an insoluble anode and a nickel cathode being employed, resulting in the deposit of the nickel on the cathode. The calcium sulphate is mixed with carbon and roasted to convert it into sulphide which is treated with chlorine and converted into chloride. The sulphur is recovered and converted into sulphuric acid which is used over again.

Copper from Ores.—L. Jumau, 883,961, April 7, 1908. Application filed Jan. 19, 1907.

Copper sulphide ore is roasted to produce copper oxide which is lixiviated at a raised temperature by an ammoniacal solution, such as a sulphate or a sulphite of ammonia or a mixture of the two. Seventy grams of copper are readily dissolved per liter of solution. The free ammonia is driven off (to be employed in further lixiviation) and the solution is then subjected at a raised temperature to the action of sulphur dioxide (obtained from the roasting of the sulphide ores). The reaction is $3\text{Cu}(\text{HO})_2 + 3\text{SO}_2 = \text{Cu}_2\text{SO}_4 + \text{Cu}_2\text{SO}_3 + \text{H}_2\text{SO}_4 + 2\text{H}_2\text{O}$. The sulphur dioxide is driven off and the sulphuric acid is used later on for lixiviation, together with the ammonia removed as before, while an extra supply of ammonia can be obtained by treating with lime the ammonium sulphate with which the lixiviating solution becomes enriched. The Cu_2SO_4 Cu_2SO_3 is dissolved in an ammoniacal solution and this is electrolyzed while simultaneously carbonic acid gas is passed through the solution so as to convert the ammonia into carbonate. The copper is readily deposited from such a solution, while the passage of the carbonic acid gas also acts mechanically to promote circulation.

Electric Discharges Through Air.

Fixation of Atmospheric Nitrogen.—A. Grau and F. Russ, 884,919 and 884,920, April 14, 1908. Application filed Oct. 8, 1907.

The inner zone of an electric arc is at the highest temperature and within it the proportion of nitric oxide formed from atmospheric air is a maximum. In order to collect the nitric oxide,

it is important to withdraw the gas mixture quickly from the inner zone of the arc. While passing from the inner zone through the outer zones of the arc the nitric oxide would become again dissociated and some of the work done within the inner zone would be undone. To prevent this the inventors withdraw the gas mixture from the inner central zone of the flame by means of a tube of small diameter so that the gas mixture does not come into contact with the outer zones of the arc. The tube is of small diameter and projects into the inner zone and is protected by means of a water or air jacket which also serves to rapidly cool the gases which are withdrawn. Patent 884,919 relates to the process, 884,920 to the apparatus.

Fixation of Atmospheric Nitrogen.—D. Helbig, 887,326 and 887,476, May 12, 1908. Applications filed Jan. 23, 1905, and Jan. 5, 1906, respectively.

Atmospheric air is subjected to the action of an electric arc within a confined chamber lined with such metallic oxides (for instance, calcium and magnesium oxides) which when heated are capable of ionizing the gases in their vicinity so as to increase their electric conductivity. The electrodes are covered with the same oxide materials, the points of the electrodes extending of course beyond these materials. In this way it is possible to use a low-tension arc, say, at 300 to 600 volts, to have a very constant arc, which is not disturbed even by a very rapid gas current. The heat of the gas mixture formed is used to preheat atmospheric air introduced into the apparatus. 887,326 refers to the process and 887,476 to the apparatus.

Ozonizer.—A. Schneller, 886,874, May 5, 1908. Application filed April 25, 1904.

In the formation of ozone by the silent electric discharge with the aid of solid dielectrics of glass, etc., it is important to prevent overheating of the dielectrics. For this purpose the latter is cooled artificially by means of oil, benzol, carbon bisulphide, etc., which acts not only as cooling agent but also forms an additional dielectric layer.

Batteries.

Gas Cell for Utilizing the Energy of Oxidation of Carbon.

E. W. Jungner, 885,054, April 21, 1908. Application filed May 15, 1907; and 884,664, April 14, 1908. Application filed May 14, 1907.

The object is to convert "the caloric energy $\text{SO}_2 + \text{O} + \text{H}_2\text{O} = \text{H}_2\text{SO}_4$ into electrical energy for the purpose of enabling the reformation of sulphurous acid by means of the subsequent reduction of the sulphuric acid by means of carbon or other suitable reducing substance according to the following reaction: $\text{H}_2\text{SO}_4 + \text{C} = \text{CO}_2 + 2\text{SO}_2 + 2\text{H}_2\text{O}$. (The principal object of this becomes clear if we consider the operation as a cyclic process, each cycle consisting of two steps indicated by the above reactions. By multiplying the first equation by 2 and adding to it the second equation we get as the result of one cycle the equation $\text{C} + 2\text{O} = \text{CO}_2$, that is the complete combustion of carbon in oxygen.) The first step of the process is carried out in the apparatus shown in Fig. 2. A vessel B of earthenware is divided into two compartments by means of the porous plate P. D and A are plates of graphite. Around D are packed small pieces G of porous graphite, moistened with a solution of nitrosyl-sulphuric acid in sulphuric acid of high concentration. On each side of A are also packed smaller pieces k of porous coke or gas coal. They are chosen of the smallest possible size in order to get a very large surface, but enough space is left between them to permit the acid produced at the surface to flow down to the bottom of the cell by gravity. The porous division wall is saturated with sulphuric acid. Through the cover L, which closes the vessel as well as separates the two compartments gas-tight, pass the conductors A and D as well as the inlet and outlet-pipes R and r. If a current of air be conducted through the pipes R and a current of

moistened sulphurous acid through the pipes r and if the poles of the battery be connected by means of a suitable resistance, a constant electric current is obtained, passing outside the battery from D to A. The reactions going on in the cell are discussed and it is concluded that the final result is a union of sulphurous acid, oxygen and water, forming sulphuric acid, while the other reacting substances remain unchanged. The sulphuric acid is formed at the pieces of coke around A and runs to the bottom of the vessel from where it is gradually drawn off through the valve k. The second step of the process—the production of sulphurous acid from sulphuric acid—is simply carried out by heating with coal, coke or the like. Some complications of the process are briefly referred to. The e.m.f. of the cell depends considerably on the concentration of the sulphuric acid and varies from 0.5 volt at medium concentra-

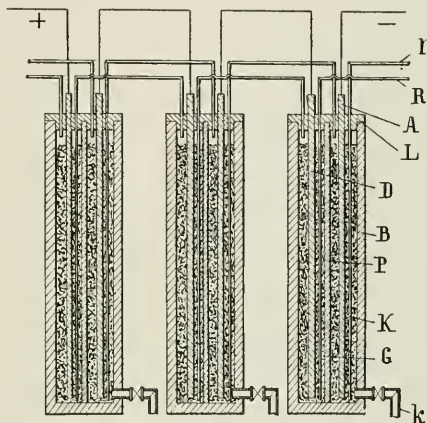


FIG. 2.—GAS CELL FOR UTILIZING THE OXIDATION HEAT OF CARBON.

tion to 0.3 volt or less at higher concentration. The inventor prefers an acid of about 80 per cent H_2SO_4 . Patent 884,664 refers to the depolarizer used, the first claim relating to "a depolarizer for galvanic elements comprising nitrosyl-sulphuric acid dissolved in concentrated sulphuric acid."

Nickel Iron Battery.—E. W. Jungner, 884,930, April 14, 1908. Application filed Sept. 20, 1904.

To increase the conductivity of the active material it is mixed with graphite particles which are coated with a thin layer of nickel by electroplating.

Active Mass of Iron.—Hugh Rodman, 884,763, April 14, 1908. Application filed May 17, 1902. Assigned to Electric Storage Battery Company.

Fe_2O_3 is inert as cathode in an ordinary alkaline electrolyte, but is readily reduced to metallic iron in an alkaline solution containing a soluble sulphide, for instance a (10 per cent) solution of caustic potash, to which has been added potassium sulphide K₂S (5 per cent).

Storage Battery.—G. A. Carpenter, 884,264, April 7, 1908. Application filed Feb. 1, 1906.

The first claim refers to "the combination of a plurality of negative plates arranged in pairs, the individual plates of each pair being insulated from each other, connections for joining together one plate of each pair, separate connections for joining together the other plate of each pair, a plurality of positive plates sandwiched intermediate of said negative plates, one positive plate having a surface substantially equal to that of one pair of said negative plates, and connections for joining together said positive plates."

Storage Battery.—M. Margulis, 884,028, April 7, 1908. Application filed June 7, 1907.

The first claim refers to "an accumulator plate consisting of a head-piece, a plurality of alternately straight and wavy lead strips suspended from the head-piece and provided with holes, a plurality of pressure strips suspended from the head-piece, and adapted to yieldingly compress the straight and wavy lead strips in the horizontal direction, and a plurality of horizontal cross rods passing through the holes of the straight and wavy lead strips and adapted to connect together the pressure strips."

Storage Battery.—W. A. F. Alt, 885,062, April 21, 1908. Application filed April 1, 1907.

The first claim reads as follows: "In a secondary battery, a plate of one sign, and a plurality of plates of the opposite sign, the aggregate area of said plurality of plates being substantially equal to the area of the single plate, means insulating the plates one from another, contact means carried by the plurality of plates adapted to engage like means, and means for separating the contact means."

Primary Battery.—C. B. Schoenmehl, 886,649 and 896,650, May 5, 1908. Applications filed May 29, 1905; 886,651, May 5, 1908. Application filed June 2, 1905; 886,652, May 5, 1908. Application filed March 29, 1906.

886,649 and 886,650 refer to a battery cover and element support. The first claim of 649 relates to "a battery bridge, and a supporting member, said bridge having a depending conical supporting-member protecting-lug extending below the solution surface." The claim of 650 reads as follows: "The combination with an electrode, of an electrode-supporting device, comprising a depending longitudinally extended protecting-sleeve having a shouldered and threaded upper portion, a member having a threaded recess extending partially therethrough, and a perforation continuing therefrom and adapted to register with the opening through said sleeve." In 651 the preparation of the copper oxide used in the cell is described. The mass of black copper oxide is first metalized (by reduction of electrolysis) and then reoxidized (by heat or electrolysis) until the compressed oxide electrode becomes sufficiently and uniformly porous. By brushing or rubbing, a coating of pure copper powder is then applied to the porous mass. 652 related to the mechanical construction of the copper-oxide electrode. The first claim reads as follows: "A negative element for batteries comprising a thin pressed cylinder of metal oxide, and a perforated and pocketed sheet of metal extending therein and having its edges turned over to engage the cylinder and to support the same."

Primary Battery.—C. B. Schoenmehl, 888,407, May 19, 1908. Application filed July 21, 1906.

Mechanical details of a compact and durable zinc-copper oxide battery, for automobiles, yachts, etc. The zinc oxide cylinder is supported from the cover and enwrapped in a perforated insulating separator, surrounded by the zinc.

Primary Battery.—W. H. McDougall and S. R. V. Robinson, 880,689, March 3, 1908. Application filed March 9, 1907.

Details of construction of a primary battery in which the various parts are directly supported from the bottom of the cell, leading the circuit wire connections through the bottom. The parts are firmly held by cement or pitch, which also seals the openings and protects the connections. The elements are entirely submerged beneath the surface of the electrolyte.

Pocket Battery.—C. M. Wheeler and H. Wilhelm, 880,703, March 3, 1908. Application filed July 11, 1907.

The first claim refers to "a pocket battery comprising a plurality of cells, and a readily removable wrapper of flexible material, comprising a central portion having a pair of side extensions folded around said cells to inclose them, and also having a top and bottom extension folded over the ends of said cells."

Automatic Montejus.

The automatic montejus, built by the Schutte & Koerting Company, as shown in the adjoining illustration, is largely used where acids or other liquors are to be raised. Its success is due to absolute reliability under even the most trying working conditions. Owing to simple construction, it cannot get out of order, and requires no attendance whatever for many years. The mechanism is entirely enclosed, stuffing boxes and other parts subject to wear and tear being dispensed with.

When the supply of liquid ceases, the montejus simply stops working, and starts of its own accord as soon as the feeding tank commences to fill. In the same way the montejus stops should the supply of compressed air or steam fail and re-starts directly when the required pressure is available.

The pressure of the compressed air or steam applied can vary 30 to 70 lb. per square inch without interfering with the regular working of the apparatus. If required, the montejus can be constructed in such a manner as to allow the pressure of the compressed air to vary within wider limits.

The montejus performs from 30 to 60 operations per hour according to the varying circumstances. As the quantity of liquid discharged at each operation is always the same, the daily or weekly output can be controlled by means of a counting apparatus, registering the number of pulsations.

To summarize the advantages of the automatic montejus over the ordinary acid egg, we mention the following:

An ordinary acid egg which is emptied twice daily requires for this output a capacity of about 500 gal. The automatic montejus of 20-gal. capacity suffices for this purpose.

The acid egg must be placed in an easily accessible position and takes up considerable floor space. The automatic montejus can be placed in any out-of-the-way position, taking up very little room.

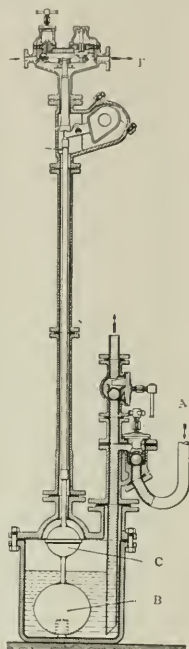
The acid egg must be attended to every 30 minutes. The automatic montejus requires no attention for years, as proved by experience.

The acid egg must be regulated by hand. Cocks and valves frequently stick or leak. In the automatic montejus all air and liquor valves are simple check valves, and are enclosed like the other mechanism. Stuffing boxes are entirely avoided.

A New Cyanide Plant.

The mill of the Montana-Tonopah Mining Co. is quite interesting in several of its technical features, as will be seen from the following description. The capacity of the mill is rated at 200 tons per day and the crushing plant is capable of handling double this quantity in a single shift if necessary.

The plant was designed by the Allis-Chalmers Company under the direction of Mr. F. L. Bosqui, consulting engineer for the Montana-Tonopah Mining Co. A remarkable feature of this plant is the short time consumed in building it and placing



it in successful operation. As soon as available for operating the entire mill after its erection it was placed in continuous operation and handled the rated tonnage practically from the start. The details had been worked out so completely in every point that the entire plant was a success commercially, metallurgically and mechanically from the start.

The ore from the mine is dumped into a steel ore bin at the head of the shaft and is drawn therefrom through an ore-bin gate of the counterbalanced type into a No. 5 Gates style "K" breaker. This crusher is set to crush all to pass a 2-inch ring. The product is delivered to a No. 5 "B" Gates continuous bucket elevator which elevates and discharges it into a Gates 40-inch x 12-inch iron-frame revolving screen without internal spiders and having 1-inch perforations. The product passing through the holes is delivered directly to the conveyor for transportation to the mill. The oversize which does not pass the holes is delivered by gravity to the two No. 3 style "D" Gates crushers. These crushers are of the special short-head type for fine crushing and are set to make a product which will pass a 3/4-inch ring. The product of these crushers is also delivered to the conveyor above mentioned.

The ore now being all reduced to about 3/4-inch size is conveyed by a traveling-belt conveyor, having a belt 14 inches wide, to the mill building. This conveyor is about 194 feet long and travels up an incline of about 40 feet in this distance. At the entrance to the mill building this conveyor discharges the ore on to another conveyor of the same size and type, but operating in a horizontal plane at an angle of 30° from the line of the other and it is about 91 feet long. This conveyor is provided with an automatic tripper or distributor which travels along the length of the ore bins in back of the batteries, delivering the ore automatically into the bins the entire length.

At the point where the ore is discharged from the first conveyor on to the second there is installed a Cole automatic sampling device to take a sample of the crushed ore. This is a very ingenious sampler and about the best devised sampler that is made for ore discharged from a belt conveyor. Mr. D. Cole, assistant manager of the Cananea Cons. Copper Co., made the first design and installation of this sampler at their mills, and it has proved a very great success. The arrangement is such that a cutter or sample scoop is made to pass through the ore stream and take a sample across the full width of the belt during its passage. The frequency of the sampler can be arranged for in the driving mechanism.

The crushed ore is drawn from the bins back of the batteries through ore-bin gates into the automatic feeders, which are of the suspended or hanging type which can be moved back from the mortars when necessary and thus give a large working space for making the usual repairs. There are eight bin gates and feeders, one for each battery.

There are forty stamps, weighing about 1050 lbs. each. They are arranged in eight batteries of five stamps each in a mortar and each battery driven by a belt and tightener from the countershaft. The batteries are made right and left-hand set in three post frames. The mortars are of the narrow rapid-crushing, quick-discharge type, and the principal battery parts are steel to insure maximum wearing life. The ore is crushed through 12-mesh screens on the mortars.

The pulp from each five-stamp battery is delivered to a 24-inch cone classifier or sizer which makes two products. The spigot, or coarse product of each, is delivered to a Wilfley concentrating table, of which there are eight in all, and the overflow from each cone is delivered to the two Dorr classifiers. The tailings from the Wilfley tables are also delivered to the Dorr classifiers by belt and bucket elevators, which are made necessary on account of the contour. In the Dorr classifiers a separation of the sand and slime is made mechanically.

It is aimed to crush all the pulp to one hundred mesh and finer in the tube mills and these classifiers separate that part

of the pulp which is already crushed to this size and it is delivered to the thickening cones for concentration on vanners, as later mentioned.

The coarse sand product from the Dorr classifiers is delivered into two 5-feet x 22-feet Gates trunnion type wet-grinding spur-gear-driven tube mills. These mills are provided with silex flint brick linings 4 inches thick and the initial charge of pebbles for each mill is 10 tons. The sands are all ground to 150 mesh or finer in these mills and each mill discharges its product into a classifying cone 4 ft. diameter. These cones are for the purpose of separating any sands from the product which might have passed through the mill without being reground fine enough and these sands are elevated back to the Dorr classifiers to be again fed to the tube mills.

The finished product is delivered to spiral sand pumps by which it is elevated to two large settling or pulp thickening cones, where the excess of water is removed and sent to the cyanide plant. The thickened pulp from the bottom discharge is delivered to 16 Standard Frue Vanning machines or concentrators having endless rubber belts 6 ft. wide. These concentrators remove and collect any fine sulphides after re-grinding, in addition to that saved by the Wilfley tables. This concentrate product is collected and dried, after which it is shipped to the smelters.

The tailings from the vanners and the overflow from the settling cones are delivered to any one of three de-watering tanks in the cyanide plant. These tanks are provided with filters through which the water is drawn off and flows to a final settling box to collect any slimes carried in suspension, after which it is delivered to a water sump tank to be pumped back for reuse in the mill.

The thickened and de-watered pulp from the settling tanks is drawn off from the bottom discharge through a pipe line connected to the suction of a centrifugal pump. This pipe line is arranged so that the contents of any tank can be drawn off and a cyanide solution pipe is connected up with same to introduce solution if desired. The pulp is delivered by the pump into the agitator tanks. There are six agitators of the Hendryx type for treatment of the pulp, this number being required on account of the predominating value being silver and requiring about 24 hours to bring same into solution.

After the required period of agitation the pulp is drawn from these tanks by a centrifugal pump and delivered into the pulp storage tank. This tank is provided with a stirring gear which keeps the pulp in gentle agitation to prevent same settling. From this tank the charges are drawn into the filter tanks as required.

The filter system used for removing the solution from the pulp is the Butters' vacuum system, consisting of two filter boxes, each containing 72 filter leaves. A charge of pulp is delivered to the filter box and after removing the solution by a vacuum applied to the filter leaves and following with the necessary washes, the pulp is discharged through the bottom from the filter leaves and is sluiced out to waste. The solution is collected in a small storage tank and is pumped through a clarifying filter press into any one of three precipitating tanks.

Precipitation is effected by means of zinc dust introduced in the form of an emulsion and with agitation by compressed air until the cycle is completed. The contents of the precipitating tanks is pumped up to the refining plant and the precipitate is collected by passing the material through filter presses where the precipitate is collected on the filters in cakes and the solution is delivered to the storage tanks for restandardizing and used again. The cakes collected are dried and shipped to the refineries for reduction to bullion.

The mill is driven throughout by electric induction motors of the Allis-Chalmers Co. and these motors are distributed so as to give unit drives to the various departments. The current used is bought commercially and is 60 cycle, 3 phase, 440 volts, transformed down from 6600 volts and distributed from the

main switchboard to the various motors located at the different points in the separate buildings.

The plant is arranged in separate buildings to conform to the contour of the country and also for protection against fire.

The elevators and pumps for handling slimes, solutions and water are installed in duplicate to insure against stopping of the entire plant when making necessary repairs to these machines.

Direct Heat Rotary Dryers.

The American Process Company, 62-64 William Street, New York, is distributing an illustrated leaflet describing its improved direct-heat rotary dryers. This type of dryer is built especially to develop large capacity and to stand heavy work, having no castings, gears, etc., and the friction driving wheels and bearing bands are made of forged steel. The continuous action of these dryers is an important feature that should not be overlooked.

The wet material is fed in at one end continuously, while the dried stuff is delivered continuously at the other end; thus no time or labor is lost in charging or discharging the machines, which in many cases is far greater than that required for the actual process of drying. As the power required to start machinery is always greater than is required to keep it in operation, it will be seen that this apparatus requires smaller power units and driving machinery than intermittent dryers.

The direct-heat principle is another important feature. The capacity of air and gases for carrying off moisture increases enormously in proportion to the fuel consumed where the higher temperatures are used. In this system the company employs this principle to the fullest extent without any injury to the material undergoing drying, and it guarantees high efficiency of evaporation on delicate material.

For handling coal or other combustible material, running low in moisture, the dryer is similar to Figs. 1 and 2. The furnace is designed with air chamber between combustion chamber and shell. A forced-draft blast pipe is branched to both ash pit and air chamber, and by blast gates the air supplied to these two points can be regulated and the temperature of the gases entering the shell can be controlled. For ordinary material, or even for coal running high in moisture, the air chamber is eliminated. The high temperature gases then come in contact with the wettest material, thus at once reducing the temperature of the gases, and as the material becomes dry the gases are

grains, refuse hops from breweries, phosphate rock, Fuller's earth, and, in fact, any and all material that is being mechanically dried.

The moving parts are very few, and so constructed that the wear is small and entirely confined to parts easily repaired or

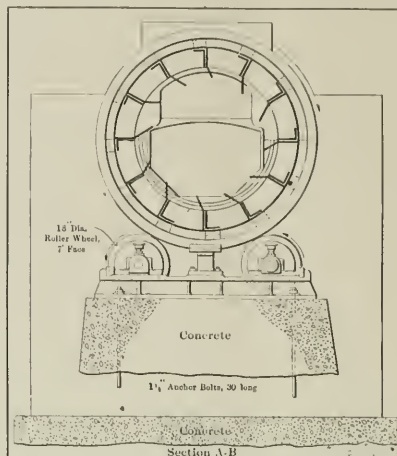


FIG. 1.—CROSS-SECTION OF ROTARY DRYER.

replaced at small cost. All working parts are exposed and can be watched by the operator without taking him from other duties.

Iron Deposits of Cuba.

In former notes on the large deposit of iron ore in the Mayari district of Cuba, which has been under development by the Spanish-American Iron Company since January, 1904, it has been stated on the basis of estimates of the engineers of the company that the deposit contains more than 500,000,000 tons of ore carrying above 40 per cent iron. The importance of the low-grade iron ores of Cuba is emphasized in a paper by Mr. Arthur C. Spencer, just published by the United States Geo-

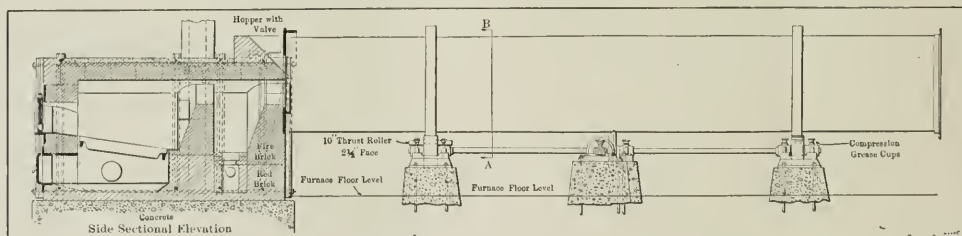


FIG. 2.—LONGITUDINAL SECTION OF ROTARY DRYER.

constantly falling in temperature and are drawn off at the discharge end of dryer thoroughly saturated, at about 350° temperature.

For calcining or roasting this process is reversed, the material passing in the opposite direction to that of the gases and discharging at the furnace end. This, however, is not a drying, but more of a calcining or roasting process.

These machines are handling by-products from chemical plants, such as sulphate of lime, carbonate of lime, grape pomace from the manufacture of tartaric acid, etc. They are also handling packing-house tankage, blood, fish scrap, brewer's

logical Survey as an advance chapter from Bulletin No. 340. In this paper Mr. Spencer discusses briefly the deposits of the Mayari field and of two other Cuban iron-ore districts, the Moa and Cubitas fields.

The Moa and Mayari districts are near the north coast of Oriente Province, or Santiago de Cuba. The Cubitas field is in Camaguey Province, formerly Puerto Principe, midway between the city of Camaguey and the north coast of the island. The aggregate amount of iron ore available in these three districts is roughly estimated at about 1,500,000,000 tons.

In physical character and manner of occurrence the ores of

the three provinces are practically identical and are very different from the well-known iron ores occurring in the Sierra Maestra near the south coast of Oriente Province. The Cuban ores that have been mined up to the present time are hard hematites with an admixture of magnetite, containing rather high sulphur and a small amount of copper.

The ores of the Mayari type come under the general head of limonite, and occur in blanket form as a superficial mantle covering massive serpentine and related rocks. Average analyses show nearly 2 per cent of chromium, rather high alumina, very low sulphur, and phosphorus below the Bessemer limit. Iron, ranging from 30 to 50 per cent, is usually above 40 per cent.

The Republic of Cuba has inherited mining laws based on the principle that the ownership of all deposits of metallic minerals is inseparable from the State. In the case of iron ores, concessions of any desired size may be acquired from the government by a process known as denouncement, the expense, including attendant surveys and title of concession, amounting to \$2.86 per hectare, equivalent to 2.47 acres. The law provides for the payment of an annual tax of \$2.50 per hectare, non-payment of which is the only cause of forfeiture. Collection of this charge has been suspended since 1901, so that at the present time mining rights, once secured by a small expenditure, may be held without further cost.

Where the surface rights to land containing mineral deposits are held by private interests arrangements must be made to satisfy all damages which may ensue, but in the case of wild or forest lands owned by the government the concessionary apparently acquires full surface rights with the title of concession. This fact is of great importance both at Moa and Mayari, where large tracts which have been held by the Church of Rome became government lands when the republic was established. With the exception of a few small claims at Moa, all the ore lands in the Moa and Mayari districts have been denounced within the last four years, so that in these districts titles are likely to be clear. In the Cubitas district most of the denouncements were made many years ago, and some of these titles to ownership are more or less clouded.

Notes.

Carborundum Industry in Europe.—According to an article of Jean Escard, in *La Lumière Electrique*, of March 7, a new carborundum plant will be started in Bodio, Turin, Italy. Older European carborundum works are said to be located at La Bathie, in Savoy (since 1894), and at Benateck, in Bohemia. We may add also the Deutsche Carborundum Werke, in Düsseldorf-Reisholz, Germany.

Copper Industry.—As an indication of a return to activity in the copper mining districts of the West, a large contract for mining machinery recently let to Allis-Chalmers Company, of Milwaukee, Wis., is of more than ordinary interest. This contract comprised an equipment for converting copper matte into blister copper, consisting of two electrically-operated converter stands with six converter shells, for the Yampa Smelting & Refining Company, Bingham, Utah. These converters are the latest improved Allis-Chalmers type, 84" x 126". The contract includes the furnishing of all accessories, such as copper molds and cars, ladles, tamping machinery, a complete silica crushing plant for converter lining, with electric motors, and a cross-compound blowing engine for furnishing blast to the converter.

Dr. John E. Teeple has resigned as director of the Industrial Laboratories, vice-president of the Biuns Chemical Works and vice-president of The Charles E. Sholes Company, and will devote his entire time to consulting chemical work and chemical engineering. Dr. Teeple's offices are located at the Hudson Terminal, 50 Church Street, New York City.

Messrs. C. F. Boehringer & Soehne of Mannheim, Germany, have discontinued their branch house in New York and have

placed in the hands of Messrs. Merck & Co., of New York and St. Louis, as their sole agents, the marketing of their B. & S. quinine and B. & S. cocaine and all other B. & S. chemicals.

Mr. Frederick F. Schuetz has moved his New York office to Room 1352 of the new Hudson Terminal Buildings, 50 Church Street, where he will continue his business as solicitor of U. S. and foreign patents, trade-marks, designs, etc.

The International Acheson Graphite Company in Niagara Falls, are about to make very important additions to their works. Ground has already been broken for a new switch-board building, while a new furnace building, 120 ft. long by 100 ft. wide, with room for 12 new furnaces, and a new grinding and storage building will also be erected. The capacity of the works will thereby be doubled. In spite of the present general industrial depression, the Acheson Graphite Company is now exceedingly busy, more orders having been received in the first quarter of 1908 than in the corresponding period in 1907. Much of this activity is due to the general interest which delocculated graphite has aroused in the various industries which are concerned with its commercial applications.

The Goldschmidt Thermit Company announces the establishment of an office and works at 103 Richmond Street, W., Toronto, Canada. The new branch was opened for business on May 1, and is under the management of Mr. E. C. Rutherford, of Toronto. A complete stock of thermit and appliances will at all times be carried at Toronto, and the branch organization will be in a position to execute promptly the welding of heavy steel sections, such as stern posts of steamships, crank shafts, etc., as well as trolley rails in paved streets, motor cases, and other broken steel sections. A fully equipped repair shop will be in operation for the repair of steel castings up to one thousand pounds in weight.

United States Dry Galvanizing Company.—On May 12 a meeting of the stockholders of the United States Dry Galvanizing Company was held in New York City for reorganizing the company. The following directors were elected: W. C. Robinson, H. H. Robinson, J. H. Clapp, C. E. Corrigan, J. Norman Martin, C. J. Kirk and H. V. Simpson. Immediately following this meeting a directors' meeting was held at which the following officers were elected: C. J. Kirk, president; W. C. Robinson, vice-president; H. H. Robinson, secretary and treasurer. The company proposes to take active steps for the immediate introduction of the dry galvanizing or Sherardizing process which has been noticed in these columns (on page 187 of our Vol. V and on page 191 of our last issue). The main office of the United States Dry Galvanizing Company will be at New Castle, Pa.

The Power and Mining Machinery Company announces that their San Francisco office has been removed to Room 217, Sheldon Building.

The Schutte & Koerting Co., manufacturers of steam and engineering specialties for chemical works and other industries, have moved their New York sales office, where they are represented by Mr. S. C. Smith, from 26 Cortlandt Street to Hudson Terminal Building, 50 Church Street. Their new catalogue of chemical works equipment, composed of bulletins of special engineering appliances used in chemical works and allied industries, is probably one of the most up to date and complete so far published by any engineering firm. This will be sent on request to engineers interested in this subject.

Messrs. Baker & Co., manufacturers of platinum ware for all purposes, with main offices and works at Newark, N. J., have moved their New York office from 120 Liberty Street to Hudson Terminal Building, 50 Church Street. The new offices are more commodious than those at the old address, and the convenience of location will easily be appreciated.

The Technical Publicity Association has elected the following officers for the ensuing year: Mr. C. T. Redfield, president; Messrs. Rodman Gilder and C. N. Manfred, vice-presi-

dents; Mr. H. H. Kress, secretary; Mr. H. M. Davis, treasurer; Messrs. F. H. Gale and C. W. Beaver, members of executive committee.

Electrolysis for High Art.—In a recent issue of *Lond. Electrician* we note that an English company is employing an electrolytic process which not only allows original bas-reliefs or art metal work to be reproduced, but permits new designs to be executed in a cheaper and more expeditious way than by hammering or casting. It is said that excellent results are obtained and photographs are given of silver reliefs of portraits of Faraday and Lord Kelvin. The scope of art metal work is very wide, extending as it does from the most artistic production to the humble but necessary bed knob, to the manufacture of flush switch plates, ornamental domes for surface switches, door plates and knobs, bell push covers, etc., all in complete sets in English and French styles. No technical details of the process are given.

Ferro Alloys.—We have received from George G. Blackwell, Sons & Company, Ltd., Liverpool, England, the fifth edition of their interesting booklet on electric-furnace high-grade alloys. It deals with the chief properties imparted to steel by the alloying elements, notably chromium, tungsten, molybdenum, vanadium, titanium, silicon and manganese. Since the fourth edition of this booklet was reviewed at great length in our Vol. IV, p. 247, we will note here only what is new in the fifth edition. As to chrome-steel reference is made to Mr. Hadfield's remark that there is a future for chrome steel with low carbon. Such a tough steel is badly wanted for wire ropes, bicycle spokes and sundry other similar materials where high tensile strength and ductility are essential. Chrome-steel has also desirable properties for electromagnetic purposes. The coercive force, especially when the material is hard, is great. Dr. Hopkinson considers that it should make good permanent magnets, which is confirmed by Dr. Bottomley's tests. (Mr. R. A. Hadfield's Iron and Steel Institute paper on alloys of iron and chromium is still the classical exposé of the subject.) It has been known in the past that boron has been experimented with by steel makers, but for what special purposes it is good has been more or less of a mystery. Messrs. Blackwell's pamphlet speaks about this as follows: "Some years ago we were asked to produce an alloy of boron and iron by one of the famous Continental steel works, and we finally succeeded in producing an alloy with 30 per cent. boron. Some important experiments with boron steels have been made, both alone and alloyed with other metals. Boron would appear to replace carbon, and produce borides of iron instead of carbides of iron. This opens up new theories in the metallurgy of steel, and the subject appears worthy of fuller investigation." The Blackwell ferroboron analyzes 32.75 Bo, 2.875 C, 0.03 S, and 0.005 P. The remarkable parallelism between the work on new metallic filaments for incandescent lamps and the use of the same elements in the steel industry is again emphasized by the fact that after the tantalum lamp has become a commercial product, ferrotantalum is now placed on the market for the steel maker. "Extensive experiments have been made by steel manufacturers with the use of tantalum in steel. This metal imparts extreme hardness to steel, and its effect under various conditions and in various percentages of tantalum, alone and also alloyed with other steels, is being very carefully investigated." The Blackwell ferrotantalum contains 65 to 75 per cent. of tantalum. The concluding pages of the pamphlet deal with other specialties of George G. Blackwell, Sons & Company, Ltd., especially their "high-speed steel alloy," their "S. A. M. alloy," fluorspar and various foundry specialties.

Geological Chemistry.—A notable work has been issued as a publication by the United States Geological Survey, a bulletin entitled "The Data of Geochemistry," No. 330 of the Survey's series, by Prof. F. W. Clarke, the chief chemist. The various chemical changes taking place in the crust of the earth, with its liquid and gaseous envelopes, the ocean and the atmosphere, are the field of investigation of the geological chemist. From

a geological point of view the solid crust of the earth is the chief object of his study, and the reactions which take place in it he classes, for convenience, under three heads: First, reactions between the essential constitution of the crust itself; second, reactions due to the aqueous envelope, and, third, reactions produced by the atmosphere. That the three classes are not sharply defined, but grade into one another, is admitted, but the distinction between them is valid enough to serve a good purpose in the arrangement and discussion of the data. Furthermore, for convenience of study, the solid crust of the earth may be regarded as made up of three layers or shells, which interpenetrate one another to some extent, but which are, nevertheless, definite enough to be considered separately. The innermost is a shell of crystalline rocks, of unknown thickness, which forms the nearest approach to the original material of which the crust was composed; next overlying this is a shell of sedimentary or fragmental rocks; and above this is the third layer of soils, clays and gravels. The second and third layers are relatively thin and are derived chiefly from the first, in great part through the transforming agency of waters and of the atmosphere, although organic life has had some share in bringing about certain of the changes. It is the history of these innumerable changes which Prof. Clarke has presented in his report. Upon the subject of geochemistry, a vast literature exists, but it is widely scattered and portions of it are difficult of access. To bring some of the data together, to formulate a few of the problems, and to present certain of the conclusions in their modern form, are the purposes which Prof. Clarke had before him in the preparation of his memoir. "It is not an exhaustive monograph upon geochemistry, but rather a critical summary of what is now known, and a guide to the more important literature to the subject. If it does no more than to make existing data available to the reader, its preparation will be justified."

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

690,319, dated Dec. 31, 1901, Isaiah L. Roberts, of Brooklyn, N. Y.

Feeds a mixture of lime and carbon, or bricks or cylinders of compressed lime, carbon and a binder, such as bitumen, asphalt, pitch or syrup, downward into an arc sprung between the lower ends of converging carbon-plate electrodes. The ends of the electrodes are raised to a white heat, and the heated charge may carry current, being then heated both by the arc and resistance. The molten carbid drops into a lower chamber closed by a gate-valve. This chamber is filled with an inert gas, taken, for example, from the zone of reduction. The plate electrodes are pivoted at their upper ends and the arcing distance between their lower ends is adjusted by screws.

701,650, dated June 3, 1902, Douschan de Vulitch and Jules D'Orlowsky, of Paris, France.

Produces porous calcium carbid, impregnated with a hydrocarbon, by running molten lime, or a mixture of lime and carbon, from an electric or other furnace into a heavy hydrocarbon liquid, for example, petroleum residues, mineral or natural tar, resin or pitch. The hydrocarbon reduces the oxid and produces carbid which, while cooling and crystallizing, is completely penetrated by the hydrocarbon in which it is immersed. The hydrocarbon also transforms any phosphorous compounds into other volatile compounds which escape. The product is suitable for the generation of acetylene, but is not acted on by damp air.

* * *

This concludes the patents on Calcium Carbide. All the patents on this subject will be found on pages 154, 108, 248, 292, 336, 382, 430, 480 and 516 of our Vol. V and on pages 39, 86, 132, 170, 218 and 264 of our Vol. VI. In the next number the instalment on Electric Furnaces will begin.

NEW BOOKS.

THE STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS. Written and compiled by a staff of specialists. Second edition—corrected. Sixth thousand, 1908. Over 1300 pages, 1300 illustrations. Flexible leather binding. Thumb index. Price \$4. New York: McGraw Publishing Co.

"The new edition is not only $\frac{1}{4}$ inch thinner, but lighter than the first edition, on account of a better and thinner quality of paper used. The book is now of truly pocket size. Thumb index tabs are provided; while these are of little use in ordinary handbooks, yet in this particular book the system of indexing is very greatly improved by the use of tabs at the beginning of each section, giving the number of the section. The system of referring to sections and paragraphs when used in conjunction with thumb tabs, has a distinct advantage over the usual system. Five thousand copies of the first edition were sold in three months and the handbook was officially adopted as a text in 30 engineering schools and colleges."

THE CHEMISTRY OF THE DIAZO-COMPOUNDS. By J. Cannell Cain. 182 pages. Bound in cloth. Price, \$3 net. New York: Longmans, Green & Co.

MODERN PIGMENTS AND THEIR VEHICLES. By F. Maire. Their properties and uses, considered mainly from the practical side, and how to make tints from them. 266 pages, illustrated. Bound in cloth. Price, \$1 net. New York: John Wiley & Sons.

THE CHEMICAL BASIS OF PHARMACOLOGY: An introduction to pharmacodynamics, based on the study of the carbon compounds. By F. Francis and J. M. Fortescue-Brickdale. 390 pages. Bound in cloth. Price, \$4 net. New York: Longmans, Green & Co.

TESTING MILK AND ITS PRODUCTS. A manual for dairy students, creamery and cheese factory operators, food chemists, and dairy farmers. By E. Farrington and F. W. Woll. 18th revised and enlarged edition. 300 pages, illustrated. Bound in cloth. Price, \$1. Madison, Wis.: Mendota Book Co.

A NEW PROOF OF THE PERMEABILITY OF CELLS FOR SALTS OR IONS. (A preliminary communication.) By Jacques Loeb. 86 pages. Paper binding. Berkeley, Cal.: University of California Press.

AMERICAN INSTITUTE OF MINING ENGINEERS. General alphabetical and analytical index. Transactions V. 1-35 (1871-1904). 79 pp., 626 pp., \$5; half-morocco, \$6. New York: Am. Institute of Mining Engineers.

A POCKET HANDBOOK OF MINERALS designed for use in the field or class-room, with little reference to chemical tests. By G. M. Butler. 307 pages, illustrated. Bound in leather. Price, \$3. New York: John Wiley & Sons.

INTRODUCTION TO METALLOGRAPHY. By Paul Goerens; translated by Fred Ibbotson. 224 pages, illustrated by diagrams. Bound in cloth. Price, \$2.50 net. New York: Longmans, Green & Co.

DECORATION OF METAL, WOOD, GLASS, ETC. By H. C. Standage. Book of recipes for all workmen in the fancy trades. 228 pages. Price, \$2 (8s. 6d.). New York: John Wiley & Sons.

MODERN ELECTRICAL THEORY. By Norman R. Campbell. 232 pages, illustrated. Bound in cloth. Price, \$2.25 net. New York: G. P. Putnam's Sons.

THE MATHEMATICAL THEORY OF ELECTRICITY AND MAGNETISM. By Ja. H. Jeans. 544 pages. Bound in cloth. Price \$4.50 net. New York: G. P. Putnam's Sons.

PRACTICAL CALCULATIONS FOR ENGINEERS; for the use of engineering students, apprentices, draughtsmen, mechanics, foremen and others practically engaged in engineering work. By C. E. Larard and H. A. Golding. 468 pages, illustrated by diagrams and tables. Bound in cloth. Price, \$2 net. Philadelphia: J. B. Lippincott & Co.

NOTES ON PRACTICAL MECHANICAL DRAWING; written for the use of the students in general engineering drawing in the University of Illinois. By V. T. Wilson. 183 pages, illustrated. Bound in cloth. Price, \$1.50. State College, Pa.: V. T. Wilson.

ENGINEERING REMINISCENCES CONTRIBUTED TO *Power and American Machinist*. By C. T. Porter. Revised and enlarged. 347 pages, illustrated. Bound in cloth. Price, \$3 net. New York: John Wiley & Sons.

WORLDS IN THE MAKING. The evolution of the universe. By S. A. Arrhenius. Translated by H. Borns. 244 pages, illustrated. Bound in cloth. Price, \$1.60 net. New York: Harper Brothers.

BOOK REVIEWS.

STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS. Twenty sections. By R. C. Beardsley, Louis Bell, H. M. Hobart, Otis Allen Kenyon, Edward Lyndon, A. S. McAllister, Kempster B. Miller, William H. Onken, E. F. Roerber, George Shaad. Bound in flexible morocco; over 1300 pages and 1260 illustrations. Price, \$4 net, postpaid. New York: McGraw Publishing Company.

Every electrical engineer has a standard of his own by which he judges the value of an electrical handbook. An opinion of the individual, therefore, is not necessarily a good estimate of average value.

Perhaps a joint statement of what authors of engineering handbooks attempt to accomplish is to present in a suitably bound, conveniently arranged book of a thousand pages a compilation of data, tables and curves and a summation of laws and principles and their application to technology which shall be most serviceable to the practicing engineer. If this has been the attempt of the authors of the Standard Handbook of Electrical Engineers, they have succeeded admirably. The 1280 pages contain live, useful matter, based upon American practice. The subject matter is conveniently and originally divided into various branches of electrical technology, and 75 of the total number of pages are devoted to an index which adds greatly to the usefulness of the book.

It is evident that the field of electrical engineering has attained such proportions that a handbook pertaining to it must necessarily omit much of the matter which is commonly found in engineering handbooks, and it is significant to note that in this handbook but 10 pages are devoted to logarithmic and other mathematical tables.

The fact that it is difficult for one man to be intimately conversant with all branches of electrical engineering undoubtedly justified the editors of this book in enlisting the co-operation of various authorities in entering into a plan of joint authorship. This plan has resulted in various features not commonly found in engineering handbooks, though it is not perfectly clear that the advantages of this plan are not to some extent counterbalanced by disadvantages. An engineer, in compiling data and information relating to his particular specialty, can write with an authority which a compiler cannot possess, and that most of the authors of this book have done this is evidenced by the fact that comparatively few references are given to the important engineering and scientific publications, to which those wishing to go more deeply into a subject can refer. A notable exception is found in the chapter on electrochemistry, in which reference to current technical scientific literature is frequently made.

A handbook compiled by a single author may possess a consistency in the treatment of various branches which cannot be secured in a plan of joint authorship, and he is less inclined to draw upon his personal note-book and has a greater willingness to credit the material which he gives to original sources.

The lack of references, however, is a feature which may not be considered a defect by many engineers who may prefer to place implicit trust in the statements and data given by the handbook to which they are accustomed to refer.

In the Standard Handbook of Electrical Engineers there is some difference in the treatment by the different authors of different subjects, though, on the whole, there is evidence of good "team work" among the experts who have made this book.

Complying with the request which has been made of the reviewer to estimate the usefulness of this book, he has subjected it to a test which involved a record on a percentage basis of information actually found and of information which was sought, taking into consideration also the rapidity with which the book could be used. The resultant marking is high. The index, with its completeness and cross-references, is useful, though not perfect, as shown by the fact that to find in it the subject of "Meters," one must look under the head of Electric Instruments.

Costs enter so largely into engineering matters that the value of a handbook is largely enhanced by plenty of cost data. This has been recognized in the section of the book dealing with transmission and distribution, and to lesser extent in that dealing with telephony and some of the other branches, while the sections devoted to transformers, motors and batteries have no cost data.

Depreciation is a subject commanding attention among engineers at the present time, but no consideration is given it in this handbook.

This new handbook, while unavoidably possessing defects and limitations, should prove of great value, not only to the practicing American engineer, but to the student as well. The importance to the engineering profession of handbook literature is great, and the question, "What qualities shall the electrical handbook possess?" is a subject of sufficient importance for careful consideration on the part of electrical engineering societies.

C. F. BURGESS.

* * *

ANNUAL REPORT OF THE MINT FOR THE FISCAL YEAR ENDED
JUNE 30, 1907. 281 pages. Washington: Government
Printing Office. (Treasury Department, Document No.
2,493.)

This report contains the valuable annual statistical tables and data for the year ending June 30, 1907. It closes a period of service of more than nine years for the retiring director of the mint, Mr. Geo. E. Roberts. During these years the organization of the service has expanded to the extent of one new coinage mint, opened in 1906 in Denver, and one important assay office, opened in 1898 in Seattle.

The capacity of all the mints has been greatly increased by the introduction of new and improved machinery. The old mint at Philadelphia, built in the early thirties, has been replaced by a splendid new one, undoubtedly the finest building ever constructed for coinage uses, and it has been thoroughly equipped with machinery of the most approved type. The new mint at Denver, although of smaller capacity than the one at Philadelphia, has a thoroughly modern and perfect equipment.

Melting is now entirely done by gas. All machinery in the mints is driven by direct-connected motors. An automatic weighing machine has been developed which rapidly and accurately selects and assort by weight all coin blanks. The most interesting technical development, however, has certainly been in connection with electrolytic refining of bullion. The report deals with this advance as follows:

"Contrary to the policy of the European mints, it has always been the practice here to conduct refineries in connection with coinage operations, being thus enabled to receive crude bullion.

"In 1908 the time-honored acid-parting methods were used in all the mints and in the assay office at New York. The partial suppression of acid fumes (it could be made only partial) was expensive and they remained a constant source of complaint from Wall street.

"In 1907 all parting and refining is done by electrolysis. Experiments in refining gold by the electric current were conducted by the melter and refiner of the mint at Philadelphia as early as 1808, with such satisfactory results that a plant for actual work was about to be installed when an inspection of the records of the Patent Office showed that his process was covered by a patent issued to Dr. Emil Wohlwill, of Hamburg,

Germany. The facts were reported to the Mint Bureau and negotiations opened with the patentee which resulted in the purchase of a right to use the process in the mint at Philadelphia. A small plant was installed in the old mint, and in August of the year 1900, 20,000 ounces of electrolytic refined gold was produced of almost absolute purity.

"Experiments looking to an equally efficient method for refining silver were prosecuted, but the problem here was a more difficult one, since in the parting of mint deposits considerable quantities of base metal have to be reckoned with, such as copper, lead, etc. In the Mochius process, then coming into extended use in private refineries, all bullion to be treated by electrolysis was and still is submitted to a preliminary cupellation, by which it was brought to so-called Dore bars, consisting of practically pure silver, with only a small percentage of gold as an impurity. The problem in mint practice was to adapt the electric current to the partation process—that is, to part bullion containing, say, one-third gold and two-thirds silver and base metals. To have accomplished this result and on a large scale reflects great credit on the melting and refining department of the mint at Philadelphia. Only an untiring devotion to the work, directed by high scientific training, could have produced the results which have been realized. Parting and refining is now done entirely by electrolysis in the mints at Philadelphia and Denver. The process had a successful trial in the assay office at New York, and will be installed in the new structure, now in process of building on Wall street. The acid plant in the mint at San Francisco is now being replaced by one in which electricity is to do the work of tons of acids.

"The gradual stages through which this revolution of methods has passed have been detailed in previous reports and find no place here. A great saving has been effected in the cost of parting and refining; valuable by-products, principally platinum, are recovered in important quantities. The refined metals, gold and silver, are almost chemically pure; the acid fumes are eliminated, and the process is a cleanly, healthy one, of scientific as well as commercial interest. Surely such results mark an era in mint methods." (More detailed technical descriptions of these electrolytic processes may be found in our Vol. I, p. 157; II, pp. 221 and 261, and IV, p. 306.)

There were received and operated upon by the refineries connected with the mints at Philadelphia, San Francisco, New Orleans and Denver, and the assay office at New York, during the fiscal year 1907, gold bullion containing 8,179,555.581 standard ounces, and silver bullion containing 19,430,818.18 standard ounces, with values of \$152,177,778 and \$22,610,407, respectively.

The earnings of the refineries were \$230,089 for charges collected, \$32,584 for surplus bullion and \$71,240 from by-products, hence the total earnings \$333,913, while the expenses were \$246,817, showing a net gain of over \$87,000.

The deposits of gold bullion at the mints and assay offices of the United States during the fiscal year 1907, exclusive of the redeposits, were of the value of \$176,580,654.53, against \$153,109,493.52 reported the previous year. Redeposits, which consists of bullion transferred from one office of the service to the other, or bars bearing the stamp of one of the offices of the service, amounted to \$65,118,805.02.

The aggregate of all deposits, including redeposits, is the total metal operated upon in the year by the mint service. This total of gold bullion received in the fiscal year 1907 was 12,991,346.109 standard ounces of the value of \$241,690,459.55, against 10,045,282.710 standard ounces of the value of \$186,888,075.26 reported the previous year.

The deposits of domestic bullion amounted to 6,139,183.740 standard ounces, of which 1,941,006.290 standard ounces were in crude condition direct from the mines operating in the different States; 701,105.411 standard ounces of refinery bars (less than 0.002 in fineness), and 3,497,077.039 standard ounces of refined bullion (0.992 in fineness and over) were received from private refineries, bromide, chlorination and cyanide works.

Electrochemical and Metallurgical Industry

VOL. VI.

NEW YORK, JULY, 1908.

NO. 7.

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH. D.....*President*
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C. E. WHITLSEY.....*Treasurer*

*Yearly subscription price for United States, Mexico and
United States dependencies, \$2.00; for all other countries, \$2.50
(European exchange, 10 shillings, 10 marks, 12.50 francs).*

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Entered as Second-Class Matter, June, 1903, at the Post Office at New
York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, JULY, 1908.

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The American Institute of Chemical Engineers and the Mining and Metallurgical Society of America.

The formation of the Mining and Metallurgical Society of America and of the American Institute of Chemical Engineers has added two new professional organizations to the list of national engineering societies of this country. Both are intended to be strictly professional societies, the membership being strictly limited to mining and metallurgical engineers and to chemical engineers respectively. The Mining and Metallurgical Society intends to enter into the following principal fields of activity: the establishment of local sections, to promote good fellowship and exchange of views; the determination of standards in engineering practice; the discussion of questions relating to professional practice and ethics; and the discussion of questions of public policy in which the profession of mining engineering is directly concerned. The American Institute of Chemical Engineers—the inaugural meeting of which is reported on another page of this issue—intends to stand for chemical technology or chemical engineering rather than for pure chemistry. Its formation is the outgrowth of the sentiment which has been so strongly manifest in recent years, that the chemical engineer is not recognized either by his brother engineers or by the public at large as fully as the importance of chemical engineering work deserves.

* * *

In view of the admirable work which the American Institute of Mining Engineers and the American Chemical Society have been doing in the past, objections to the formation of the new societies have been repeatedly and honestly put forward in recent months, but such objections are now useless and out of order. The Mining and Metallurgical Society of America and the American Institute of Chemical Engineers have been formed; they have been formed by enthusiastic professional men to further the best interests of their profession. In recording this fact, we express the sincere hope that the new societies will fulfill all the useful purposes which animated their founders and incited them to the step they have taken.

Hard Spots in Steel Castings.

It is with particular pleasure that we call attention to the article of Mr. A. P. Scott on hard spots in steel castings, the first part of which appears in this issue. The subject is interesting enough in itself and for this reason Mr. Scott's exceedingly careful analysis of the causes of the particular hard spot discussed in his article is very valuable. But what makes Mr. Scott's paper so peculiarly attractive is the able manner in which modern methods of experimental research are made use of and the broad view which the author takes in extending the results of the experiments of his special case to general conclusions on diffusion phenomena in solid solutions. We intend to comment on Mr. Scott's paper at greater length after publication of the concluding instalment in our next issue.

Copper Refining as an Engineering Proposition.

Mr. F. D. Easterbrooks' article in this issue, on the silver refinery of the new addition to the Raritan Copper Works, completes his description of this highly interesting plant, which is certainly one of the finest examples of modern copper refining practice and is evidence of a very high order of engineering ability and technical knowledge of its designers. Mr. Easterbrooks' serial consisted logically of three articles. In our May issue the power plant was described. Cheap power is the necessary foundation of the commercial success of copper refining and of any electrolytic industry in general, and the new Raritan power plant is an interesting example of the possibility of generating power cheaply even with steam, the ideal condition of a 100 per cent load factor being, of course, the principal factor in favor of low cost. In our June issue the copper refinery proper was described. The primary object of a copper refinery is, of course, to refine copper, and it is perfectly true, as has been said, that the advent of the dynamo made electrolytic copper at once possible and necessary. The electrical industry needs pure copper and the cheapest way of purifying copper is by electrolytic refining. Electrolytic copper refining would have become a commercial necessity, even if there had not been the possibility of recovering thereby at low cost the precious metal impurities. As the situation now is, the easy recovery of the gold and silver forms one of the strongest points of electrolytic copper refining, and Mr. Easterbrooks' serial is thus logically concluded by the description of the silver refinery.

* * *

The refining of silver is another example of the universal rule, that for the sake of continuity of operation every electrolytic process requires relatively pure starting materials; or, in other words, electrolytic methods are chiefly applicable to the last refining step of a process only. In the recovery of silver and gold from the slimes of the copper refinery, electrolysis is employed only in the final parting of the bullion, which is preceded by the slime-room treatment, where the copper is extracted and the slimes pressed and washed, and by the treatment in the furnace room, where the slimes are melted and blown to bullion. With reference to the electrolytic separation, the Balbach-Thum process, used at the Raritan works, will be found interesting in comparison with other methods. Of particular interest are Mr. Easterbrooks' notes on the loss of silver in melting with open furnaces, since practice confirms here the consequences of theory. Nothing has ever been published to our knowledge on the actual losses of silver in practice, and we may express the hope that reliable information on this point may become available, since the matter is exceedingly interesting and important. The Raritan practice of recovering the values mechanically carried into the flues, by means of a combination of settler and water scrubber, should attract the attention of all who are interested in the smelter fume problem for the double purpose of making the fumes harmless and recovering any values contained in the same.

* * *

There is one fundamental fact that is thoroughly emphasized by this account of the new plant of the Raritan Copper Works, that is the difference between the ways of carrying out any

electrochemical process in the laboratory and on a large scale in practice. It is hardly possible to find a simpler electrolytic process for laboratory work than copper refining, while a great many complications arise on a large scale. Factors which are plainly negligible in the laboratory become of importance on a large scale. There is, of course, no real difference between the reactions themselves on a small and on a large scale. The solution of the problems which has been found in the laboratory, can be and must be usefully employed on a large scale. But new additional problems arise which must be solved for successful large-scale operation, and these new problems are of an essentially different character. After a process has been worked out in the laboratory, it becomes an engineering proposition—engineering problems arise which have nothing to do with the electrochemical reaction, but rather with the general arrangement of the works and of the process so as to make it a good paying proposition—in short, problems of organization. The solution of such problems as the organization of the purchasing department, for instance, have a very decisive influence on the financial results. Naturally this, like various other problems of organization, are not dealt with in Mr. Easterbrooks' serial, which is restricted to a description of the metallurgical works, chiefly from a constructional point of view. But the lay-out of the works as a whole and the arrangement of the details as well, as described in Mr. Easterbrooks' articles, show that a master mind was responsible for the design. Under such circumstances it is specially gratifying to note that in this wonderfully arranged organization the research laboratory was not forgotten—a small detail perhaps in the whole organization, but one which indicates the farsighted and progressive spirit which is characteristic of modern metallurgical engineering.

Price and Uses of Steel.

In June occurred the first clear break from the level of finished steel prices which had been artificially held over from the period of intense activity and heavy demand that came to an end very abruptly early in the fourth quarter of last year. Formal reductions of \$4 a ton were made in merchant steel pipe, bars, hoops, bands and small structural shapes, and of \$2 a ton in wire products, plates and shapes. The eagerness with which the steel manufacturers joined in a movement to maintain former prices when demand slumped, indicates that the price movement of the future will not be subject to the passing whims of individuals anxious to maintain a competitive position irrespective of consequences. It will rather be governed by the general fundamental conditions which surround the industry, to which respect must be yielded however strong is the sentiment among manufacturers for co-operation in the regulation and maintenance of prices. The price reductions just made were in line with these general conditions, whatever may have been the proximate causes. The general fundamental conditions to which we refer are the amount of iron ore in the ground awaiting utilization, the capacity in existence for converting it into iron and steel, and the store of iron and steel now in existence and in actual employment. It has already been pointed out in these columns that we made more pig iron in the United States in the past ten years than we had made in all the previous years, and that the major part of the iron

thus made survives as a store to be reworked at intervals and to be added to as our needs may indicate, having full reference to the actual cost of making such additions.

* * *

This view of the matter is not as common as it should be. There was recently held at the White House a conference on the conservation of our natural resources, which was attended by the governors of 44 States and by a number of other distinguished men. Reference was made to the loss which our national wealth undergoes through erosion and the carrying to the ocean of enormous quantities of fertile soil every year; to the devastation of our forests; to the waste in coal-mining, and to the rapidity with which the rate of mining iron ore has been increasing. The mining of iron ore, as a depletion of our national resources, was spoken of in the same breath as the waste in coal-mining, the erosion of the soil and the depletion of the forests, just as if to mine a ton of iron ore and convert it into steel was to wipe it out of existence, or lose it, as a ton of soil is lost if it is carried into the ocean, a ton of coal is lost if it is burned, or a tree is lost if it is cut up and exposed to the elements and bacteria without a new tree being grown in its place. It was a loose way of thinking and quite unworthy of the distinguished talent which was gathered at the White House Conference.

* * *

One of the most distinguished speakers at the conference, Mr. Andrew Carnegie, who is as much entitled to his little joke as the next man, presented his joke, but failed to arouse the risibilities of his audience. He spoke feelingly of the rapidity with which we have been "exhausting" our stores of iron ore and coal, and urged that we should use every means to save our iron ore, by turning to other materials, and in addition by turning from railroad to water transportation, as requiring less steel. By using less iron ore the coal required to smelt and convert it into finished steel would also be conserved. His statistics of our resources were 10,000,000,000 tons of iron ore and 2,500,000,000,000 tons of coal. The point to Mr. Carnegie's joke was that it requires less than a ton of coal to smelt a ton of iron ore and convert the pig iron into finished steel, so that to put all our iron ore into use as steel would require less than two-fifths of one per cent. of all our coal. He should have had a friend in the audience to explain the point and start the laughter.

* * *

In the ten years, 1898 to 1907 inclusive, there was made in the United States about 181,500,000 tons of pig iron; in all the previous history of the industry there was made a trifle less than 170,000,000 tons, making a total production, to the beginning of this year, of about 350,000,000 tons. That is four gross tons per capita of our present population. Is that iron lost? The most cursory inventory will find a great part of it, and it is fairly safe to assume that three tons per capita have survived and are in actual employment to-day. The visible supply of iron ore in the United States is sufficient to make 5,000,000,000 tons of pig iron, or 57 tons per capita. That would give us 60 tons per capita instead of three tons. How long will it be until our requirements increase twenty fold? The visible supply of iron ore, however, has been increasing so rapidly that there is no prospect of the rate of smelting overtaking

the rate of addition. These additions are made in two ways, by the discovery of new material and by the discovery of new processes, whereby what is the worthless material of one period becomes the commercial iron ore of the next period. The electric process, for instance, as thus far developed, adds enormously to the resources, although the addition is so new that the material which it can attack has not yet been added to the estimates of our iron ore reserves.

* * *

Steel is competitive with wood in nearly all uses to which wood is put. If the White House Conference had declared that the freer use of our iron ore reserves constituted the most practical means of saving our timber it would have made a sensible declaration. Instead of this, its deliberations tended to spread the impression that iron ore should be saved as coal, timber and fertile soil should be saved. If the permanent organization which is to be formed as an outgrowth of the conference wishes to do practical work, it is hard to see how it can do better than to endeavor by all possible means to increase the use of steel and to encourage the development of processes looking to the making of steel more cheaply, and to the use of material not now regarded as commercial iron ore. It certainly should be its attitude that steel should be sold at the lowest possible prices.

* * *

As we have already said, the reductions just made in steel prices are in line with the needs of the case. The industry itself needs all the help which can thus be afforded, because the enormous addition made to our store of iron and steel in actual employment during the past ten years, more than doubling it indeed, raises the serious question whether the present capacity can find full employment except by a fresh spreading in the uses for steel, through the medium of lower prices. Assuming our present store of iron and steel as the equivalent of between 250,000,000 and 300,000,000 tons of pig iron, the present capacity, with additions now in course of erection, making a total of some 31,500,000 tons of annual capacity, can double that store in eight or ten years. New uses will find themselves, if the price is made right. The steel railroad tie constitutes one instance. The principal objection which has been urged against it is that it is too light. Nothing made it too light except the high price per pound at which it was desired to sell it. Taking the form of steel tie which has been most used, it may be said that if it were sold at the same price per pound that steel rails brought at one time, almost double the material could be put into it, at the same price per tie that has been asked. Then it certainly would not be too light. If the tie were increased in weight by two-thirds, it would require about 100,000,000 tons of steel to lay the present mileage of track with it.

* * *

The trend of events is clearly in the direction of finding a much larger use for steel through the medium of prices more in keeping with what the steel industry has shown it can do, whereby it will again find full employment, and whereby the depletion of our forests can be retarded, if not absolutely arrested. The last thing the conservators of our national resources need fear is the exhaustion of our iron ore reserves. Their work should lie in exactly the opposite direction to encourage the use of this iron ore.

The Iron and Steel Market.

June has brought some interesting developments in the iron and steel trade. The Lake Superior ore interests put in force a 50-cent concession from the 1907 ore prices, which they had previously been lined up to maintain for the present season, while on June 1 and June 9 reductions were made in all important finished steel products except sheets and tin plates, which were reduced January 6, and standard rails. In this latter branch the question is not one of the base price, but of the charging of an extra for the new specifications calling for an improved rail. To renounce the demand for extras would be equivalent to a reduction, and some move in this direction will probably be made.

ORE PRICES.

The new schedule on Lake Superior ores is as follows, f. o. b. Lake Erie docks:

Old range Bessemer	\$4.50
Mesabi Bessemer	4.25
Old range non-Bessemer	3.70
Mesabi non-Bessemer	3.50

The base analyses are as follows: Bessemer, 55 per cent iron content, natural state, with 10 per cent moisture and .045 per cent phosphorus, when dried at 212°, non-Bessemer, 51.50 per cent iron content, natural state, with 12 per cent moisture. The new basis was adopted for the season of 1907, the previous guarantees having for many years been as follows: Bessemer, 63 per cent iron when dried at 212°, equivalent to 56.70 per cent iron in the natural state; non-Bessemer, 60 per cent iron when dried at 212°, equivalent to 52.80 per cent in the natural state. The change of base was in itself equivalent to an advance in price, and the retention of the same phosphorus content, with the reduced iron basis, was equivalent to a slight loosening in the phosphorus restriction, a point which does not appear to have been commented on, although it is of some consequence considering the increased difficulty in securing ores suitable for the manufacture of Bessemer pig iron. During the high pressure in 1906 and 1907 a great deal of Bessemer pig iron and Bessemer steel was made which ran closer to .12 per cent phosphorus than to .10 per cent, that being the recognized outside limit.

Subject to the base guarantees ruling in the different seasons, Lake Superior ore prices have been as follows, prices in 1898 being given as they showed the lowest average on record:

	Old Range Bessemer.	Mesabi Bessemer.	Old Range Non-Bessemer.	Mesabi Non-Bessemer.
1898	\$2.75	\$2.20	\$1.80	\$1.75
1905	3.75	3.50	3.20	3.00
1906	4.25	4.00	3.70	3.50
1907	5.00	4.75	4.20	4.00
1908	4.50	4.25	3.70	3.50

Scarcely any mining was done during the winter and spring, and mining has been relatively light to date. The season movement promises to run 20,000,000 tons or less, or less than half the 1907 record. With so long a period of quiescence, monthly shipments toward the close of the season promise to be quite heavy.

FINISHED STEEL PRICES.

The reductions in official prices of finished steel products have been as follows:

June 1. Steel bars, bands, hoops and light structural shapes reduced \$4 a net ton to 1.40c. base, half extras on the bar card, for merchant steel bars and bands; to 1.50c. base, half extras on the bar card, for small structural shapes, these being angles, channels and tees under 3 inch, and angles 3 x 3 less than $\frac{1}{2}$ inch thick, and to 1.80c. base, full extras on the hoop card, for hoops.

June 9. Merchant steel pipe reduced two points or about \$4 a net ton, to 75 off list for "jobbers' carloads," making the inside price 76 and 5 off list, on sizes $\frac{3}{4}$ to 6-inch inclusive, the net price on such sizes being therefore about 2.28c a pound.

Plates reduced \$2 a net ton, to 1.60c. base, for tank quality, with extras for widths over 100 inches, thicknesses under $\frac{3}{4}$ inch, and quality.

Structural shapes reduced \$2 a net ton to 1.60c. base, this covering angles and tees and beams and channels 15-inch and under; tees, 1.65c. and beams and channels over 15-inch, 1.70c.

Wire products reduced \$2 a net ton, to 1.80c. base, for plain wire, 1.95c. base, for wire nails, and 2.40c. base, for galvanized barb wire.

BILLET AND SHEET BAR PRICES.

The official prices on billets and sheet bars were reduced June 9 by \$2 a net ton, making the new prices as follows:

Billets, \$25, delivered Pittsburg; delivered prices, \$25, Pittsburg, plus the following additions: to points taking less than 50 cents freight from Pittsburg, the full freight; to points taking 50 cents to \$1 freight, 50 cents additional; to points taking \$1 to \$3 freight, one-half the freight additional; to points taking more than \$3 freight, the full freight additional, less \$1.50.

Sheet bars, \$27.50, delivered Pittsburg; delivered prices, \$27 f. o. b., Pittsburg, plus the same additions as in the case of billets, except that Canton, Ohio, and Buffalo, N. Y., are \$27.50 delivered.

The old sheet bar prices were quite well observed, and the new prices are being equally well observed. The old billet price, on the other hand, was largely nominal, as some mills were making cut prices. Besides this, the bulk of the movement was under scale contracts, based upon the Bessemer pig iron average, and the decline in Bessemer pig iron had brought the adjustment prices on such contracts down to between \$24 and \$25.

SHEETS AND TIN PLATES.

The leading interest in sheets and tin plates and the independent manufacturers held a very well attended meeting in Pittsburg, June 12, and decided to attempt to maintain former prices, despite the \$2 reduction in sheet bars, whereas declines in sheet bars have usually been accompanied by similar reductions in the finished products. Reports of a number of cases of shading in sheets were reported to the meeting, but not a single case was reported of shading in tin plates, and as tin plate mills were running to substantially full capacity, while the sheet mills were running to less than 40 per cent of normal, it was decided not to disturb the situation at this time. Tin plate is \$3.70, black sheets 2.50c, and galvanized sheets 3.55c, less 5 cents per 100 lb. rebate.

THE MARKET MOVEMENT.

At the time of the steel bar reduction about 100,000 tons of contract business was reinstated at the new price, specifications having been withheld, and heavier specifications are now expected on this business. At the same time fresh contracts for about 125,000 tons of bars were entered. This business was chiefly from wagon and agricultural implement makers, for their season July to June inclusive. Jobbers and other buyers were restricted to deliveries to October 1, at the reduced price.

Outside of the steel bar business new buying has been very light in finished steel products. Mill activity, as a whole, was slightly less in June than in May, continuing the progressive diminution which has been in progress since about April 1. Operations are expected to be very light in July.

The opinion is almost universally entertained among both sellers and buyers that there will be a marked increase in iron and steel activity after July, although in no quarter is it expected that the trade can reach its full measure of activity at any time this year, and serious doubts are entertained whether the full productive capacity can be engaged even next year, except at further reductions in finished steel prices.

PIG IRON.

The announcement of the reduction in Lake Superior ore prices has not adversely affected pig iron prices. The market

has been very quiet, but furnacemen, as a rule, are firm in their views. Foundry iron in the Chicago district is about 25 cents higher, and in Eastern Pennsylvania about 25 cents lower. In the Central West there was a good buying movement in basic pig iron about June 1, the American Steel Foundries taking 30,000 tons for Alliance, and 10,000 tons for St. Louis, the Allegheny Steel Company taking 7,000 tons, and the Page Woven Wire Fence Company making a sliding contract for three years, covering a total of about 50,000 tons. Basic pig advanced about 25 cents in consequence of this movement, and is now \$15.25 to \$15.50, valley furnace. Bessemer pig remains at \$16, valley. Foundry iron in the valleys is firmer, at \$14.60 to \$15.

Note on the Structure of a Brittle Sheet of a Very Low Carbon Steel.

By ALBERT SAUVEUR,

Professor of Metallurgy in Harvard University.

In the course of an examination of the structure of a brittle sheet of very low carbon steel, one of the treated samples was found to exhibit a structure so peculiar as to warrant, I think, the recording of it in these columns.

The brittle sheet referred to contained about 0.05 per cent of carbon, and the brittleness from which it suffered was un-



FIG. 1.—STEEL SHEET, HEATED TO 835° C. AND COOLED WITH FURNACE. MAGNIFIED 50 DIAMETERS.

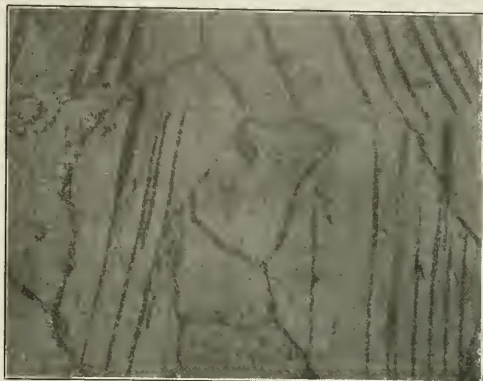


FIG. 2.—MAGNIFIED 100 DIAMETERS.

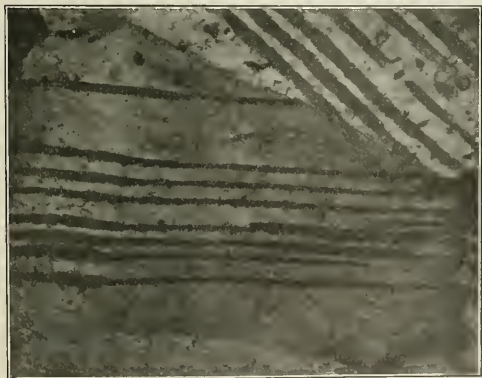


FIG. 3.—MAGNIFIED 100 DIAMETERS.

An excellent movement occurred in Southern iron, at special prices, \$11.50 Birmingham, and lower, and by the middle of the month the Southern market had firmed up to \$12 to \$12.50, Birmingham.

Since March pig iron production has been declining slowly but steadily. From the record rate of a trifle over 28,000,000 tons a year, reached in October, it declined to about 12,600,000 tons in January, then advanced to about 14,800,000 tons in March, declining to about 14,000,000 tons in June.

doubtedly of the kind described by Stead and must have been produced by a prolonged heating at a relatively low temperature, say between 600 and 700 degrees Centigrade. As an evidence of this, it will suffice to mention that fracture (by punching) always occurred at an angle of 45 deg. to the direction of rolling, which is the most marked characteristic of this peculiar brittleness.

A number of strips were cut from this sheet and subjected to different treatments. One of them was heated to 835 deg. C. in a muffle gas furnace and allowed to cool slowly with the furnace. The sample was then polished and etched with a solution of nitric acid in absolute alcohol, when the structure illustrated in Figs. 1, 2 and 3 was brought out.

It will be noted that many of the ferrite grains contain a number of thick bands which are always parallel in the same grain, but whose direction is generally different in different grains. It will also be noted that they come to an abrupt stop at the junction lines of the ferrite grains, and in no case is there a band to be found crossing the boundary line between adjacent grains. It is natural to infer that the direction of these bands very probably indicates also the orientation of the small cubic crystals of which each grain of ferrite is formed, for it is well known that the orientation of these small cubic crystals is the same in any one grain, but changes as we pass from one grain to the next. It might, therefore, reasonably be supposed that each band is composed of a string of these small crystals, differentiated from their neighbors by a more vigorous attack on the part of the acid of the etching solution. Assuming this interpretation to be correct, how shall we account for this arbitrary and selective action of the acid which picks out for its attack parallel strings of the small crystals while leaving the surrounding crystals practically unaffected?

Or, are these bands some of Ewing's slip bands? This seems hardly possible for slip bands to cover the entire area of the strained grains, while in the structure shown here each ferrite grain contains but a very few bands, in no case more than eight.

American Institute of Chemical Engineers.

The committee appointed at Atlantic City last June to consider the advisability of the formation of an American Institute of Chemical Engineers, decided that a mail vote would be the best method of determining the sentiment of American chemists toward the proposed new organization. This mail vote was decisive in showing a strong sentiment for the formation of the institute, and as a consequence a meeting was called for the purpose of organization.

This inaugural meeting was held in the Engineers' Club, Philadelphia, Pa., on June 22. It was called to order at 10:30 a. m. Dr. C. F. McKenna was made temporary chairman. He introduced Dr. Samuel P. Sadtler, who welcomed those in attendance to Philadelphia, and spoke of the chemical industries of Philadelphia, and of the field of the chemical engineer.

Dr. McKenna then delivered an address, in which he referred to the fact that the chemical engineer was not as fully recognized as the mechanical engineer or the civil engineer, and expressed the conviction that an American Institute of Chemical Engineers, with its membership restricted as to age and other qualifications (such as education and experience), would do much to better the existing conditions. Dr. Hunicke, of St. Louis, followed with an address in which he outlined his ideas of the chemical engineer and the scope and importance of his work.

In the afternoon session the committee on constitution reported a draft of the constitution, which defined the purposes of the institute, the proposed qualifications of the members, dues, etc. The yearly dues were fixed at \$15, with no initiation fees at present, the age limit at 30 years, and 10 years' practical experience in chemical engineering (from which a different number of years are deducted for college and university degrees which the applicants may have obtained).

The committee on nominations presented the following names for the officers of the institute: President, Samuel P. Sadtler, Philadelphia; first vice-president, C. F. McKenna, New York; second vice-president, A. Hunicke, St. Louis; third vice-president, E. G. Acheson, Niagara Falls; treasurer, W. M. Booth, Syracuse; secretary, J. C. Olsen, Brooklyn; auditor, R. K. Meade, Nazareth, Pa.

The directors will be for one year: Ludwig Reuter, Berkeley, Cal.; Thorn Smith, Isabella, Tenn.; H. F. Brown, Wilmington, Del.; for two years: J. M. Camp, Duquesne, Pa.; C. A. Catlin, Providence, R. I.; Eugene Haanel, Ottawa, Canada; for three years: G. P. Adamson, Easton, Pa.; David Wesson, Wilmington, Del., and E. Gudeman, Chicago, Ill.

The report of the committee was accepted and the above gentlemen were declared the elected officers of the institute.

The evening was spent in a general discussion of the plans of the institute.

About 85 gentlemen have already joined the American Institute of Chemical Engineers, but a much larger number will probably apply for membership now after the institute has been actually formed.

CORRESPONDENCE.

Boiling Point of Zinc.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—Naturally I have read with interest the articles of Professor Richards on the Metallurgy of Zinc, now appearing in your journal.

I notice that he uses 930° C. for the boiling point of zinc at 760 mms. This figure was obtained by Violle in 1882 and is undoubtedly too high. As will be explained later, high figures are usually recorded because of peculiarities of the methods.

Ingalls, in his *Metallurgy of Zinc*, page 2, gives 920° C. as the "latest determination," but does not cite his reference.

I have determined the boiling point of zinc many times and have found values varying between 918° C. and 922° C. (at 29.7 inches of mercury the value is 916° C.), using in each case pyrometer and couple tested by the Reichsanstalt.

It is quite easy to get readings too high unless an apparatus of iron or Acheson graphite is used because the temperature gradient is large.

Another source of error is caused by the zinc vapor absorbing oxygen and forming ZnO, a solid. This causes more air to be sucked in because the pressure in the "tester" is thereby lessened. These phenomena can raise the observed boiling point as much as 100° C. or to 1020° C.

It can be prevented by using a very small hole for the "test-hole" and covering the zinc well with granular charcoal.

With these precautions, using an apparatus similar to that used in my work on the reduction temperature (see *Am. Electrochemical Society's Transactions*, April, 1904; also this journal, vol. II, p. 185, the apparatus being illustrated on p. 186), and by raising the temperature slowly not over 0.5° C. per minute, the upper and lower readings (i. e., the start of the zinc flame and its stopping after ebullition) should agree within two degrees, the mean of three determinations within 1° C.

At high pressures up to 60 lbs. per sq. in. absolute pressure, or 45 lbs. gauge, the readings are much less accurate. Probably an extreme error of 3 per cent is involved.

But with a strong steel apparatus, while working for the Lungwitz Reduction Co., we did obtain without much trouble satisfactory determination of the boiling temperature of zinc at 60 lbs. absolute, quite different from those calculated by Professor Richards. I hope to publish an account of this work some day in your journal.

HARTFORD, CONN.

WOOLSEY McA. JOHNSON.

Diaphragms.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—Supplementing the article by Mr. F. B. Crocker in the April issue of *ELECTROCHEMICAL AND METALLURGICAL INDUSTRY*, I believe an account of some of my work with diaphragms, already published elsewhere¹, however, will be found useful to chemists taking up this problem.

In the first place, one is quite safe in saying that asbestos is the best all-round material available for diaphragms. The main difficulty is to support the asbestos in the position it is to occupy. I have made successful diaphragms, by forcing with moderate pressure, wads of wet asbestos into 5/8-in. to 1-in. round holes bored into 5/8-in. to 3/4-in. boards.

Another and probably better method is to place two or three thicknesses of asbestos paper between two perforated sheets of lead, wood or hard rubber, according to the solution to be withstood. The resistance of a diaphragm of this kind, made of 4-lb. lead, plentifully perforated with 3/8-in. holes, of course opposite each other in the two sheets, is practically negligible. In a sulphate solution of uniform temperature the lead is practically permanent, and does not act as a metallic conductor. It cannot, in fact, under usual conditions.

The best diaphragm I know of for ordinary weak acid solutions is made as follows: Sift powdered sulphur evenly over a 3/4-in. asbestos "mill-board," and heat the sheet evenly an hour or so to just above the melting point of sulphur. Repeat the operation with the other side. It takes from 1/4 to 3/4 lb. of sulphur to the square foot of the mill board. This diaphragm is plastic when heated, and in solutions *does not soften at all*. It expands slightly though and should be kept in acid water two or three weeks before using in any kind of rigid construction. The resistance is somewhat higher than without the sulphur, but the diffusion is smaller.

TEBY, N. Y.

ANSON G. BETTS.

¹Lead Refining by Electrolysis. By A. G. Betts (New York: John Wiley & Sons).

A Laboratory Experiment to Illustrate the Changes in Magnetic Properties Occurring at the Thermal Critical Points in Steel.

By H. M. BOYLSTON.

The experiment described below is not of itself new, having been performed for several years in the Metallurgical Laboratory of Harvard University by students under the direction of Prof. Sauveur, but the results obtained in the past two years with an improved form of apparatus have been so satisfactory as to justify a brief description of the method and apparatus used. Two suggestions for the practical application of the principle involved are also briefly described at the end.

The Apparatus consists essentially of three parts; namely, an electromagnet, a support for the test-piece, and a Le Chatelier thermo-electric pyrometer.

The electromagnet, A, Fig. 1, is arranged vertically and consists of a large number of turns of fine insulated copper wire wound on a porcelain tube. This wire constitutes the exciting coil and is supplied with an electric current of the proper strength. Inside the fireproof tube is suspended a soft iron core, *d*, $\frac{5}{8}$ inch in diameter and having its lower end ground smooth normal to the length of the core. The lower end of the core should extend down not more than three inches below the magnet coil in order that a fairly strong magnetic field may be maintained. The coil is also protected from the heat of the blast lamps used for heating the test-pieces by several gaskets, *w*, made of heavy asbestos board.

The support, B, Fig. 2, consists of two concentric porcelain tubes wedged tightly together and arranged so that the upper end of the outer tube projects about $\frac{1}{4}$ inch above the end of the inner tube. The upper end of both tubes is ground smooth normal to the length of the tubes. The internal diameter of the outer tube should be but very little larger than the diameter of the test-piece. The upper end of the outer tube thus serves as a protecting collar to the thermo-couple which would otherwise be subjected to the full heat of the blast lamps when the test-piece is raised by the magnet.

The magnet and the support are held in place on an ordinary ring-stand by means of burette clamps and rings.

A Le Chatelier thermo-couple, C, properly insulated, say by means of an ordinary clay pipe-stem, is suspended inside the porcelain support in such a position that the hot junction, *h*, reaches nearly to the top of the previously drilled test-piece, *s*, when the latter is not being attracted to the magnet. The pipe-stem has the additional advantage of serving to nearly close the support tube to currents of air which otherwise would rise through the tube and cool off the test-piece.

The portion of the thermo-couple which extends through the center of the test-piece is bare, the two wires being very close together but not touching. These wires act not only as a temperature indicator, but as a guide upon which the steel piece slides freely up and down when attracted or released by the magnet.

The cold ends of the thermo-couple are of course connected by means of copper leads in circuit with an ordinary pyrometric galvanometer, *g*. It has been found convenient to place the cold ends of the thermo-couple in an ordinary wide-mouth bottle, *j*, containing distilled water. A thermometer placed in the water will indicate the correction which must be added to the galvanometer reading to give the true temperature of the hot junction and therefore of the steel piece at any given moment. The needle of the galvanometer, of course, must be set at zero when connected with the couple in the air. This method of finding the correction has been found more convenient than the usual method of surrounding the cold junction with melting ice and is very nearly if not quite as accurate.

The Experiment.—A piece of $\frac{1}{2}$ -inch round steel about $\frac{3}{4}$ inch long is carefully drilled longitudinally through its center

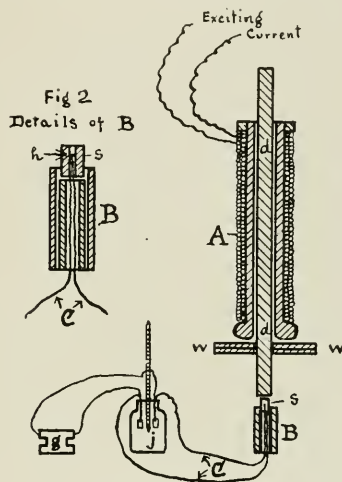
(conveniently with a $\frac{1}{8}$ -inch drill) and the ends of this test-piece are ground flat normal to its length.¹

The drilled test-piece is now placed over the hot junction of the thermo-couple, resting upon the inner tube of the porcelain support so that the upper end of the steel remains not more than $\frac{1}{8}$ inch below the lower end of the unmagnetized core. The hot junction of the thermo-couple is now inside the steel piece and a little below the top surface of that piece. The upper end of the outer porcelain tube acts as a protecting collar to the portion of the thermo-couple necessarily bared when the test-piece is lifted later by the magnet.

The exciting current of the electromagnet is now turned on and remains on during the entire experiment.

Loss of Magnetism on Heating at the Critical Range.—

The test-piece, which is now clinging to the magnet, is heated



FIGS. 1 AND 2.—APPARATUS FOR ILLUSTRATING CHANGES.

gently and gradually² by means of two blast lamps, one on each side, and the temperature at which the piece ceases to be attracted to the magnet is carefully noted. It should be found to correspond closely to the thermal critical point (Ac_{3-2-1} in high-carbon steels, Ac_{3-2} in medium high-carbon steels, and Ac_1 in low-carbon steels) of the steel as determined in the usual way by means of heating and cooling curves.

This correspondence may be automatically checked by noting that very nearly at the instant the test-piece drops the galvanometer needle will stop short, or even reverse its direction of motion slightly in the case of high-carbon steels, indicating that the well-known absorption of heat or retardation of heating is taking place.

Recovery of Magnetism on Cooling at the Critical Range.—

The heating should be continued until the piece is at white heat, when the lamps should be withdrawn, allowing the piece to cool in the close vicinity (within $\frac{1}{8}$ inch) of the magnet. The temperature at which the piece is again attracted should

¹ The experiment is best carried out with high-carbon steels containing more than 0.80% of carbon as such steels have only one critical point, Ac_1 (on heating) or Ar_{3-2-1} (on cooling), and that point is very marked, but the figures given in Table 1 show that steels with less carbon give good results, remembering that the critical points determined by this method would be Ac_2 and Ar_{2-3} in medium carbon steels and Ac_1 and Ar_1 in low-carbon steels.

² The fact that the lower $\frac{1}{4}$ inch of the test piece is not heated as rapidly as the rest of the piece because of the porcelain collar surrounding it does not interfere with the measurement of the temperature at which the piece loses its magnetic properties for the hot junction is situated near the top of the $\frac{3}{4}$ -inch long test-piece.

be carefully noted. It will be found to correspond closely to the critical point (Ar_{3-2-1} , Ar_{3-2} or Ar_2 , depending upon which steel is used) as otherwise determined.

The experiment should be repeated several times and the average of the results determined.

Results: Table 1 gives results obtained by the writer and an assistant using the magnetic method as compared with results obtained by a class of advanced students, using pieces of the same steels and the cooling curve method.

During the past two years a large class of students who had had no previous experience with the apparatus obtained the results shown in Table 2, using in each case a high-carbon steel.

All the results shown were obtained under the supervision of the writer in the Metallurgical Laboratory of Harvard University under the general direction of Prof. Sauveur, whom the writer wishes to thank for several helpful suggestions.

As a Commercial Testing Method.—The method described in this paper being much more perfectly performed than the cooling curve method might be used profitably in a commercial way for determining the critical points Ac_{3-2-1} and Ar_{3-2-1} in an unknown high-carbon steel where the best quenching temperature, for instance, might be desired. In this case ten readings or more could be taken in about twenty minutes. To do away with the effect of the personal equation of the observer who watches the test-piece the magnet core might be connected in a weak electric circuit with the test-piece, together with a buzzer or other indicator which would mark instantly the breaking or closing of the circuit caused by the fall or rise of the test-piece.

As an Automatic Device for Hardening Steel—It is suggested that the apparatus described might be used as an automatic quenching device for small steel articles without the aid of a thermo-couple. By making the electromagnet of the proper size and suspending small pieces of steel from it the latter on heating would drop off, each as it reached its critical point Ac_{3-2-1} , falling into a trough containing the proper quenching bath. The heating perhaps might be evenly accomplished by means of a hollow cylindrical electric resistance furnace without a bottom.

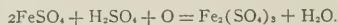
Harvard University.

Industrial Electrochemistry in Russia

An interesting Faraday Society paper of Prof. N. PILTSCHIKOFF, of the Technical Institute of Khar'kov, gives a brief review of the electrochemical industries in Russia.

Besides three works, making caustic soda and bleaching powder, viz., Lubunoff, Solvay & Cie., Zabkowieck Electrochemical Cie. and the Russian "Elektron" Company, there are several copper-refineries, viz., that of the Siemens Company at Kalakant, which is not at present working, and a factory at Moscow which produces annually 500 tons of electrolytic copper, 1 ton of silver and about 80 lbs. of gold; tin, nickel and chromium are also prepared. There is also a similar factory at Petersburg, and a plant for the extraction of copper from its ores is erected at the "Medianke" mine at Boleslav.

"At the latter place the method of Laschinsky is used. According to his observations the salts of iron, even in small quantities, are oxidized at the anode to a sulphate very rich in iron:



This minimizes the effect of the current and lowers the quality of the deposit. To avoid this oxidation the plates are covered with lead which forms the anode in the electrolytic bath, while the liquid is continually stirred. The effect of this arrangement is remarkable, the iron is no longer oxidized, and copper is deposited regularly in amounts up to 1.15 grms. per ampere-hour."

Several electrochemical methods are about to receive a tech-

nical application. Among these, the process of fixation of atmospheric nitrogen by Gorbov and Mitkievitch, professors in the Institut Polytechnique in Petersburg, may be cited. Their furnace (Fig. 1) consists of a chamber B, whose upper part is

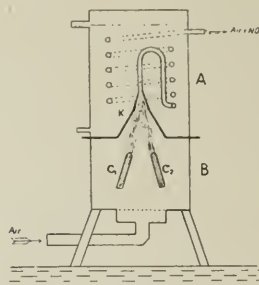


FIG. 1.—GORBOV-MITKIEVITCH FURNACE.

is then cooled in the worm, which is placed in a bath A filled with water or oil, whose temperature is not allowed to exceed a certain limit.

Fig. 2 shows the operation of a Gorbov & Mitkievitch furnace with a 12-kw. arc. The abscissae show the percentage volume of nitrous oxide obtained, while the ordinates are the weight of nitric acid in grams per kilowatt-hour. "This furnace has been compared with that of Birkeland and Eyde, and is found to be much more economical, while its construction is simpler."

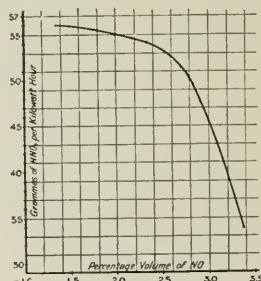


FIG. 2.—RESULTS OF PRODUCTION OF NITRIC ACID.

formed by a funnel K, connected to a worm in which the products of combustion can be cooled. The arc is formed between carbon or metal electrodes C_1 and C_2 , and fills the whole of the funnel. ("Continuous or alternating current can be used. The terminal voltage is from 1,000 to 3,000 and across the arc from 600 to 1,500.") A current of air draws the arc into the worm, in whose mouth is formed a "bunch of fire," through which all the air has necessarily to pass. It

is then cooled in the worm, which is placed in a bath A filled with water or oil, whose temperature is not allowed to exceed a certain limit.

Fig. 2 shows the operation of a Gorbov & Mitkievitch furnace with a 12-kw. arc. The abscissae show the percentage volume of nitrous oxide obtained, while the ordinates are the weight of nitric acid in grams per kilowatt-hour. "This furnace has been compared with that of Birkeland and Eyde, and is found to be much more economical, while its construction is simpler."

Prof. Kloboukoff, of Kharkov, has perfected the tanning of hides by the electric current, which prevents any fermentation in the bath. But these experiments have been interrupted by the death of Kloboukoff.

Dr. K. Danilevsky has studied the deposition of electrolytic copper on leather. The leather with its contained copper is harder, resists the action of lime to a greater extent, and wears out less quickly.

Successful experiments

have been made at Petersburg on the purification of various waters by ozone. The process is not yet widely used, probably for economical reasons. The author has, however, seen at Moscow a very powerful and economical ozonizer due to Prof. Sokotoff.

Association of Electrical Engineers of the Iron and Steel Industry

The first annual meeting of the Association of Electrical Engineers of the Iron and Steel Industry will be held in Philadelphia on June 24 and 25. Mr. G. H. Winslow, 559 Frick Annex, Pittsburgh, Pa., is the secretary and treasurer.

The following committees have been appointed: Finance, Messrs. E. W. Yearsly, G. H. Winslow, J. Farrington; papers, E. W. Yearsly, P. D. Brown, G. W. Richardson, G. M. Sturges; library, G. H. Winslow, L. R. Palmer; board of examination, B. R. Shover, J. C. Reed, L. R. Palmer; editing, L. R. Palmer, G. H. Winslow; standardization, T. P. Townsend, G. W. Richardson, G. M. Sturges.

Metallurgical Calculations.

By J. W. RICHARDS,

Professor of Metallurgy in Lehigh University.

Condensation of Zinc and Mercury Vapors.

The temperature at which a metallic vapor, like zinc or mercury, commences to condense, depends upon the vapor tension curve of the metal and the amount of other uncondensable gas with which it is mixed. These intermixed gases reduce the pressure upon the metallic vapor, and lower the temperature at which the vapor becomes saturated vapor. The phenomenon is exactly analogous to the "dew point" of air and the precipitation of rain.

Problem 135.

A roasted zinc ore contains 15 per cent Fe^2O^3 and 70 per cent Zn O . It is reduced by excess of carbon, in a retort.

Required:

(1) The average composition, by volume, of the gas mixture entering the condenser, assuming no CO^2 in it.

(2) The "dew point" of the mixture at which it begins to deposit zinc.

(3) The percentage of zinc escaping condensation, if the gases leave the condenser at 600°C .

Solution:

(1) Per kilogram of zinc there is used, assuming complete reduction:

$$1 \div (0.70 \times 65/81) = 1.78 \text{ kg.}$$

Oxygen in 1.78 kg. of ore:

$$\text{As Zn O} = 1 \times 16/65 = 0.246 \text{ kg.}$$

$$\text{As Fe}^2\text{O}^3 = 1.78 \times 0.15 \times 48/160 = 0.080 \text{ "}$$

$$\text{Sum} = 0.326 \text{ "}$$

$$\text{CO formed} = 0.326 \times 28/16 = 0.57 \text{ "}$$

$$\text{Volume of CO} = 0.57 \div 1.26 = 0.45 \text{ m}^3$$

$$\text{Volume of Zn} = 1.00 \div 2.93 = 0.34 \text{ m}^3$$

$$\text{Sum} = 0.79 \text{ m}^3$$

Percentage composition of gases:

$$\text{CO} = 57 \text{ per cent}$$

$$\text{Zn} = 43 \text{ " (1)}$$

(2) If the barometric pressure is assumed normal, then the zinc vapor supports

$$760 \times 0.43 = 327 \text{ mm}$$

and the temperature at which the mixture becomes saturated with zinc vapor is found from the table (see June number of this journal, p. 250) to be 847° . (2)

This is 83° below the normal boiling point of zinc.

(3) From 847° down, the vapor in the retort will be always saturated, its tension being found from the tables. The proportion of original zinc condensed, or remaining uncondensed, cannot be inferred simply from the vapor tension at any temperature. For instance, the vapor tension of the zinc at 600°C . is 12 mm of mercury column. The CO gas leaving the condenser at this temperature will, therefore, be at a tension of $760 - 12 = 748 \text{ mm}$, and will be accompanied by $12/748$ of its volume of zinc vapor; as it came into the condenser it was accompanied by $327/433$ of its volume of zinc vapor. The ratio of these two quantities or proportions represents the real fraction of the zinc escaping uncondensed; that is, the proportion escaping condensation, in terms of the total zinc concerned, is $12/748 \div 327/433 = 0.016 \div 0.773 = 0.008 = 0.8 \text{ per cent}$.

The same result can be calculated in several ways. One is based on the datum that at any given temperature zinc vapor is $65 \div 28 = 2.3$ times as heavy as CO gas.

Problem 136.

Numerous attempts have been made to reduce Zn O continuously in a blast furnace, and condense the zinc from the gases. In such a case, the gases will consist of zinc vapor, carbon monoxide and nitrogen, and the deficit of reduction heat must be obtained by the burning of carbon to CO at the region of the

tuyeres. A low charge column must be used in order that the gases pass out hot enough to carry the zinc. Assume the gases to escape at 900°C ., and the furnace to lose by radiation and conduction, etc., an amount of heat equal to the sensible heat in the blast used.

Required:

(1) The amount of fixed carbon to be charged into the furnace, per 2000 lb. of zinc.

(2) The composition of the gases leaving the furnace.

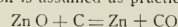
(3) The temperature at which these gases will begin to deposit zinc or become saturated with zinc vapor.

(4) The proportion of the zinc they carry which will escape from the condensers, as vapor, at 600°C .

(5) The pressure necessary to apply to the furnace to keep the zinc in the melted state at the minimum temperature of reduction, 1033°C .

Solution:

(1) If the reaction is assumed as practically



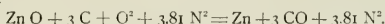
there is needed for reduction, per 2000 lb. of zinc

$$2000 \times (12/65) = 369 \text{ lb.}$$

There is in this reaction a deficit of heat, which is per 65 parts of zinc concerned simply

$$(\text{Zn, O}) - (\text{C, O}) = 84,800 - 29,160 = 55,640.$$

This deficit can only be made up by burning more C to CO right at the tuyeres. If two more atoms of carbon were burned we would have a little more than enough heat. We will, therefore, assume the reaction at the tuyere region as the using of one atom of carbon for reduction and of double as much for supplying the heat deficit, and since one volume of oxygen is accompanied by 3.81 volumes of nitrogen, the whole reaction will be



The amount of fixed carbon necessary is approximately three times that necessary for reduction only and amounts, per 2000 lb. of zinc, to

$$36 \times \frac{2000}{65} = 1108 \text{ lb. (1)}$$

(2) The furnace gases, therefore, contain, by volume,

$$\text{Zinc vapor} = 1 \text{ volume} = 12.8 \text{ per cent.}$$

$$\text{Carbon monoxide} = 3 \text{ " } = 38.4 \text{ "}$$

$$\text{Nitrogen} = 3.81 \text{ " } = 48.8 \text{ " (2)}$$

(3) The gases will be saturated with zinc vapor when the partial pressure of the zinc, which is

$$760 \times 0.128 = 97 \text{ mm}$$

is equal to the maximum tension of zinc at the temperature attained. This is at 745°C ., as seen from inspecting the vapor tension tables, or 185° below the normal boiling point of zinc. (3)

(4) The relative volume of zinc vapor to uncondensable gas in the original gases is

$$\frac{12.8}{87.2} = 0.147$$

In the gases issuing from the condenser at 600° it would be

$$\frac{12.0}{748} = 0.016$$

The proportion of the zinc escaping condensation under these conditions would, therefore, be

$$\frac{0.016}{0.147} = 0.109 = 10.9 \text{ per cent. (4)}$$

By cooling the gases to the melting point of zinc, it would be possible to leave uncondensed only

$$\frac{0.165}{759.8} \div 0.147 = 0.0014 = 0.14 \text{ per cent.}$$

(5) If it was a question only of keeping pure zinc from vaporizing at 1033° , in the absence of other gases, we could at once consult the vapor tension table, and find 2.2 atmospheres as the actual tension of zinc vapor at 1033° , corresponding to 1.2 atmospheres effective pressure upon the furnace. But in the gas mixture coming from the furnace the zinc is practically one-eighth, by volume, of the gases, which means that it sustains one-eighth of the pressure upon the whole. It would, therefore, take a tension of

$$2.2 \times 8 = 17.6 \text{ atmospheres}$$

to keep all this zinc in the liquid state, corresponding to an effective pressure of 16.6 atmospheres. (5)

This is an entirely impracticable working condition and shows the practical impossibility of the schemes upon which much money have been spent for reducing zinc ore to liquid zinc in a blast furnace run under high pressure.

Problem 137.

In the metallurgy of mercury, the average ore contains 2 per cent of Hg S and is roasted by the use of 10 per cent of its weight of wood having an average composition of water 20 per cent, carbon 32, hydrogen 5.3, oxygen 42.7. Assume that just enough air enters to completely burn the sulphur and carbon, that the ore and air used are dry.

Required:

(1) The percentage composition by volume of the roaster gases.

(2) The temperature at which the mercury will commence to condense.

(3) The proportion of the mercury present escaping as vapor if the gases pass out of the condensers at 100° C., at 50° C., at 15° C.

Solution:

(1) Per 1000 kg of ore, containing 20 kg of Hg S, there must be burned

$$\begin{aligned} 20 \times 32/232 &= 2.8 \text{ kg of sulphur.} \\ 100 \times 0.32 &= 32 \text{ " " carbon.} \end{aligned}$$

requiring of oxygen:

$$\begin{aligned} 2.8 \times 1 &= 2.8 \text{ kg.} \\ 32 \times 32/12 &= 85.3 \text{ "} \\ \hline \text{Sum} &= 88.1 \text{ "} \\ \text{Nitrogen accompanying} &= 293.7 \text{ "} \\ \hline \text{Air} &= 381.8 \text{ "} \end{aligned}$$

Composition of the gases:

$$\begin{aligned} \text{Hg} &= 17.2 \text{ kg} = 17.2 \div 9.00 = 1.91 \text{ m}^3 = 0.595 \text{ per cent} \\ \text{SO}^2 &= 5.6 \text{ "} = 5.6 \div 2.88 = 1.91 \text{ "} = 0.595 \text{ "} \\ \text{H}^2\text{O} &= 68.0 \text{ "} = 68.0 \div 0.81 = 83.95 \text{ "} = 26.15 \text{ "} \\ \text{N}^2 &= 293.7 \text{ "} = 293.7 \div 1.26 = 233.10 \text{ "} = 72.66 \text{ "} \end{aligned}$$

$$321. \text{ "} = 100.00 \quad (1)$$

(2) In reality, each of these gases possesses the volume of the gas mixture, and is at the above percentage of the normal barometric pressure upon the mixture. The tensions of the different constituents of the mixture are, therefore,

$$\begin{aligned} \text{Hg} &760 \times 0.00595 = 4.52 \text{ mm} \\ \text{SO}^2 &760 \times 0.00595 = 4.52 \text{ "} \\ \text{H}^2\text{O} &760 \times 0.2615 = 198.75 \text{ "} \\ \text{N}^2 &760 \times 0.7266 = 552.20 \text{ "} \\ \hline &760.00 \text{ "} \end{aligned}$$

The mercury will, therefore, commence to condense when the temperature of the gas mixture is that of mercury vapor at a maximum tension of 4.52 mm. From the vapor tension table of mercury we find this to be 161° C., or 196° below the normal boiling point of mercury. Above this temperature the gas mixture is not saturated with Hg vapor and no condensation can occur. (2)

(3) In the gas mixture, the mercury vapor is equivalent to

4.52/760 of the volume of the whole, or 4.52/755.48 of the volume of the other gases. This latter proportion is 0.00598. At 100° C. the uncondensed mercury vapor can have a tension of 0.285 mm, leaving 759.715 to the other gases, and giving the ratio of mercury vapor to other gases 0.000375. Since the other gases have remained constant in amount, the proportion of mercury remaining uncondensed is

$$0.000375 \div 0.00598 = 0.063 = 6.3 \text{ per cent.}$$

If the temperature of the mixture is reduced to 50° C., the mercury vapor remaining can exert a tension of only 0.013 mm and the water vapor only 92 mm. The other gases present will therefore sustain $760 - (92 + 0.013) = 668$ mm. In the original mixture the Hg and H²O vapors are, respectively, equivalent to

$$\begin{aligned} \text{Hg} &4.52 \div 556.72 = 0.0081 \\ \text{H}^2\text{O} &198.74 \div 556.72 = 0.3570 \end{aligned}$$

of the volume of N² and SO² together.

In the gas escaping at 50° the Hg and H²O will be equivalent to

$$\begin{aligned} \text{Hg} &0.013 \div 668 = 0.00002 \\ \text{H}^2\text{O} &92. \div 668 = 0.1377 \end{aligned}$$

of the volume of the same gases.

The proportions of the Hg and H²O escaping uncondensed at 50° will, therefore, be

$$\begin{aligned} \text{Hg} &0.00002 \div 0.0081 = 0.0025 = 0.25 \text{ per cent} \\ \text{H}^2\text{O} &0.1377 \div 0.3570 = 0.3857 = 38.57 \text{ per cent.} \end{aligned}$$

By exactly similar reasoning, using the maximum tensions of Hg and H²O at 15° (0.0009 mm and 13 mm, respectively), the proportions of each to the N² + SO² are

$$\begin{aligned} \text{Hg} &0.0009 \div 747 = 0.0000012 \\ \text{H}^2\text{O} &13. \div 747 = 0.0174 \end{aligned}$$

and the proportions escaping condensation would be

$$\begin{aligned} \text{Hg} &0.0000012 \div 0.0081 = 0.00015 = 0.015 \text{ per cent} \\ \text{H}^2\text{O} &0.0174 \div 0.3570 = 0.04874 = 4.874 \text{ per cent} \end{aligned} \quad (4)$$

The differences between these percentages and 100 will be the proportions of these materials condensed to the liquid state.

METALLIC MIST OR FUME.

When zinc or mercury are in the state of vapor their atoms are each separate from other atoms. Chemically speaking, their vapor molecules are mon-atomic. On condensing to the liquid state we do not know whether the atoms come together into compound molecules or whether they simply come closer together. In either case, the molecules of the liquid metal, as the temperature is reduced low enough to form them, exist at first as isolated molecules, constituting the liquid metal in its finest possible state of sub-division, so small that it is for the time being practically still a gas. If, however, we give these liquid molecules the possibility of uniting to liquid masses, we get the latter. This is a matter principally of reducing the surface tension which holds the liquid molecules each to itself as a sphere. Contact with a rubbing surface, with dust particles, filtration through cloth, or even electrification (perhaps a magnetic field) reduce this surface tension and cause agglomeration into liquid masses which precipitate.

The amount of liquid or solid particles thus held in suspension and escaping with the current of uncondensable gas is entirely independent of the quantity escaping as true vapor, which has been calculated above, except in so far as they are both functions of the amount of said uncondensable gas. The velocity of the escaping current is a large factor in the amount of mist, because the carrying power of gas for mist particles varies probably with the cube of its velocity, so that halving the velocity of the issuing gas will diminish greatly this source of loss. Large settling chambers in which the mist can deposit, because of stagnation of the gas current, and large rubbing surfaces, are effective means for catching or depositing the mist. Filtration through bags is still more effective.

In the case of zinc, the solidifying point is 420° , while condensation from the state of vapor begins at, say, 860° . In this interval only can the condensed particles, as a mist, collect

together to liquid zinc. If the temperature passes quickly through this range, the particles have little chance to agglomerate into liquid masses, and the proportion which chills into solidified mist particles is increased. These solidified mist particles, analogous to "hoar frost" in nature, form the well known "blue powder" of the zinc works. It settles in large settling chambers, and is in extremely fine particles, mostly under 0.01 mm in size. It is quite easy to collect all the zinc in this form if the vapor is chilled suddenly and the resulting gas settled properly or filtered.

The loss of mercury or zinc as mist or hoar frost is therefore, to be considered entirely apart from the loss as true vapor; it may be smaller than the latter and it may be larger; its amount varies particularly with the nature of the settling apparatus and the velocity of the gases as they escape. The theory as to its amount under any given set of conditions would be very difficult to elaborate, and the data for doing so with exactness are practically unknown. The best that can be done at present is to study the loss as mist or hoar frost in actual practice, experimentally, and tabulate the actual results as a guide for future metallurgical use.

The Silver Refinery of the New Addition to the Raritan Copper Works.

By FRANK D. EASTERBROOKS.

Silver Refinery.—The slimes deposited in the bottom of the tanks from both the No. 1 and No. 2 tank houses are treated in this department for the recovery of fine silver and gold.

The process of smelting and refining is divided into three stages, each of which is carried out in a separate room. Fig. 1 shows a ground plan of the refinery.

On account of the high monetary value of the material handled, precautions have to be taken to guard against losses other than metallurgical. In Fig. 6 is shown the arrangement of lockers, etc., for the employees, which may be of sufficient interest to describe them in greater detail.

Special provision was made for the comfort and convenience of the working force, white porcelain-lined wash stands, hot

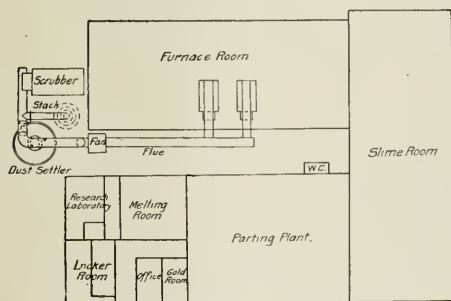


FIG. 1.—PLAN OF SILVER REFINERY.

and cold water and shower baths being provided, together with two lockers for each employee, one for his street clothes and the other for his working apparel, the idea being that if comfortable, scrupulously clean and sanitary surroundings were provided, a standard would be established, whereby the force could be held and maintained at that degree of cleanliness and carefulness which is so essential in the successful operation of a refinery treating electrolytic slimes.

All employees enter the No. 1 locker room by the door nearest the entrance, remove their outside street clothes, place them in their respective lockers and pass through the door leading to the No. 2 locker room. This door is opened from

either side only by a key which is in the possession of the special watchman. After donning their working clothes, the men go directly to their respective departments without passing through either of the others. On leaving work the reverse takes place, the laborers first washing up (the waste waters from the sink going to suitable settling tanks) before passing through the door to the No. 1 locker room. All the windows of the refinery are protected by small diamond mesh screens.

The buildings were constructed of brick with monitors running the length of the roof for ventilating purposes, with the

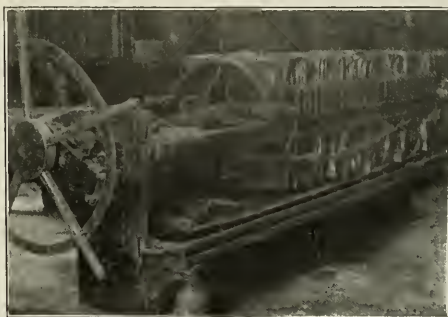


FIG. 2.—FILTER PRESS FOR SLIMES.

exception of the melting room in the parting plant, where two 48-in. Burt ventilators were installed. The roof trusses in the slime room are of timber, while those in the furnace building and parting plant are of steel.

A 5-ply asphalt and slag roofing laid over hook tile was used in place of planking in the parting plant to prevent the possibility of a fire from spontaneous combustion, due to the action of nitric acid fumes on wood. All flashing throughout was of 16-oz. copper, and exposed woodwork both inside and outside of the building was covered with three coats of Toch Bros. iron oxide paint.

The following gives an outline of the process for smelting slimes:

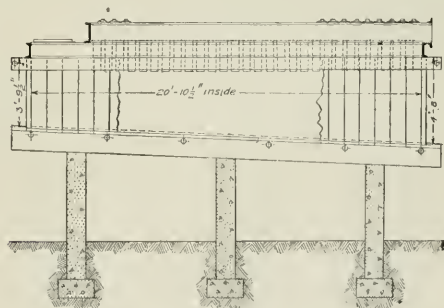


FIG. 3.—SECTION THROUGH SCRUBBER.

Stage.	Department.	Treatment.
1st	Slime room.	Copper extracted. Slimes pressed and washed.
2d	Furnace room.	Slimes melted and blown up to bullion.
3d	Parting plant.	Gold and silver separated electrolytically.

Slime Room.—The general scheme for handling the slimes here is by the gravity system. After being screened first

through a copper plate perforated with 1-in. holes, then through a slotted copper screen equivalent to 40 mesh to remove as much of the copper as can be removed by screening, the slimes are pumped from the tank house basement to receiving tanks in the top of the slime room by a centrifugal pump of the same design as that used for circulating electrolyte in the tank house.

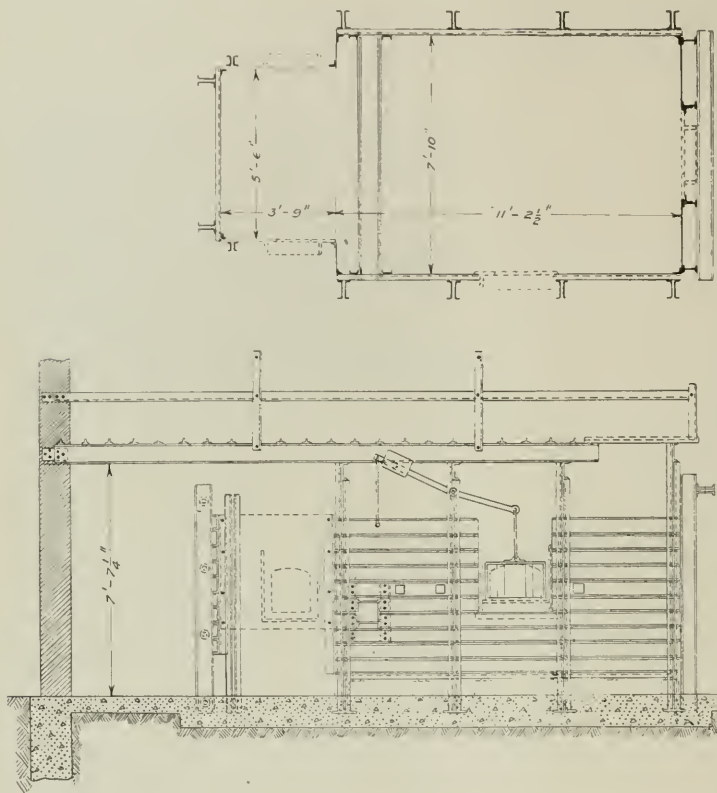


FIG. 4.—SLIME FURNACE.

All overflow water, together with the water used for washing slimes in the filter press, is returned to the tank house, where it is added to the electrolyte to make up losses by evaporation, etc., the water first passing through a system of settling tanks arranged on the gravity plan to allow the lighter particles to settle. The slimes are transferred from the receiving tanks to the agitators through a pipe and plug seat located in the bottom of the receiving tank.

In the agitators, which are large, circular, lead-lined tanks, the slimes are boiled with sulphuric acid, sodium nitrate being added to hasten the process. Paddles constructed of lead containing 10 to 12 per cent antimony and turned by machinery, prevent the slimes from settling to the bottom of the tanks in a solid mass. Practically no difficulty whatever is experienced with the machinery in this room due to acid fumes, and the use of machinery tends toward reducing labor costs.

After the copper in the slimes is reduced to a small amount they are transferred to an "egg"—a lead-lined cast-iron vessel, from which, by means of compressed air, they are forced into the Bushnell filter press, where the slimes are pressed and washed free from copper sulphate. Fig. 2 shows a photograph of the filter press.

The plates and rings of this press are made of antimonial lead heavy enough to withstand the pressure used. Sulphuric acid solutions gradually attack plates made of copper or copper alloys.

The pressed slimes are unloaded directly into trucks which are run in under the press. After sampling and weighing they are ready to be transferred to the furnace department. It will be noted that this is the first point where a determination is made of the actual amounts of silver and gold recovered from the copper bullion.

The amount of copper remaining in the screened slimes varies from 8 to 18 per cent; in certain cases where anodes are cast directly from converter copper, it will assay as high as 50 to 53 per cent. The leaching of this copper from slimes is made necessary because of the fact that when smelted in furnaces copper and silver form a compound assaying very high in silver, which is "slagged off." This not only diminishes the immediate output, but also increases the amount of silver tied up in process, thereby extending the time necessary to ship as fine product.

The method of extracting copper by boiling with acid and nitre is a slow reaction, despite the fact that copper exists in the slimes in a minute form. The process leaves much to be desired. Ten to 15 days' time is required to ship slimes as fine silver and gold, calculating from the date they are received from the tank house.

Furnace Room.—In this department the slimes are smelted in furnaces and refined by means of air blown on the molten surface to about 98 to 99 per cent gold plus silver.

Fig. 4 shows views of the furnace used to smelt slimes. The hearth is made of chrome brick.

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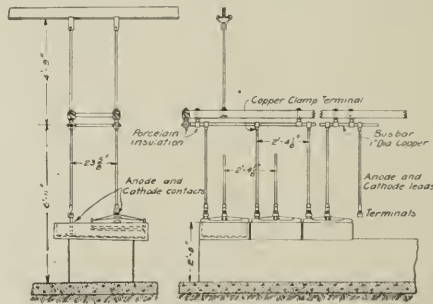


FIG. 5.—SECTIONS OF COMPLETE CELLS.

and is 5 ft. 6 in wide by 8 ft. long. Oil is used for fuel, burners furnished by the Rockwell Engineering Co. being used. In the refining process, tellurium is among the last of the impurities to leave silver bullion, its presence re-

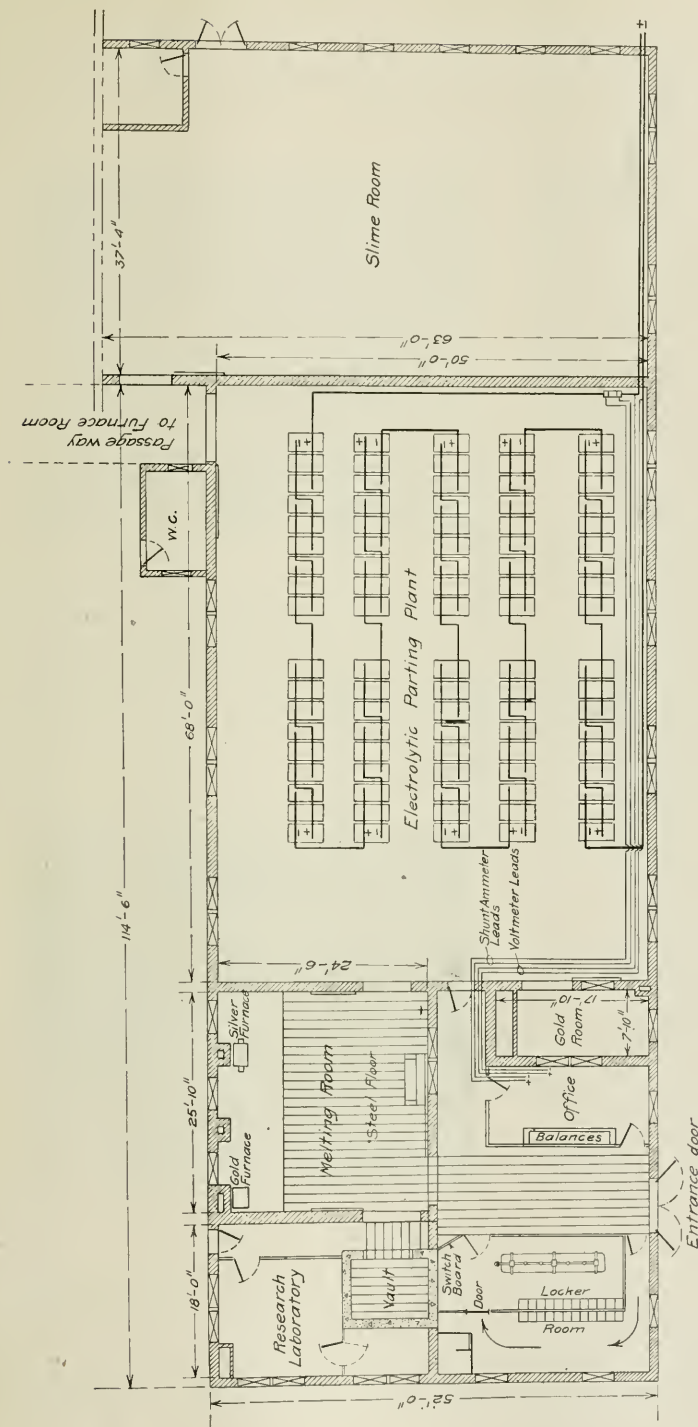


FIG. 6.—FLOOR PLAN OF PARTING PLANT AND LOCKER ROOM.

quiring a prolonged operation with an accompanying loss of silver. The reason why loss of silver occurs when melted in open furnaces has been pointed out by Prof. J. W. Richards in his series of Metallurgical Calculations. (See ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, March, 1908, page 115.) His theoretical conclusions are confirmed in actual practice.

The refined bullion is dipped from the furnaces and cast by hand into thin plates, which form the anodes used in the electrolytic parting plant.

No lead is used in refining slimes, and the slags, after sampling and weighing, are sent to the copper furnaces. This tends, of course, toward a gradual increase of impurities in the material handled.

For recovering values mechanically carried into the flues, or volatilized during the smelting process, an arrangement of flues shown in Fig. 1 was constructed. The gases are exhausted from the furnaces by a fan which forces them first through a large settler, to allow the greater part of the dust to settle, and then through a water scrubber, before escaping to the air. In Fig. 3 is shown a view of this scrubber.

Slimes as charged into the furnaces contain from 40 to 50 per cent silver, together with considerable gold, depending upon the copper bullion refined.

There is need of intelligent, earnest, systematic research work in the method of refining slimes, particularly on slime room and furnace methods, and the establishment of a research laboratory by the consulting engineers, Messrs. Fischer and Nevill, was in line with the advanced policy pursued by them throughout the construction of the plant.

Parting Plant.— After investigating different processes in use for the electrolytic separation of gold from silver, the method devised by Mr. William Thum, which is a modification of the method described in full in his patent specification (U. S. Patent No. 58,035), was the one adopted as best suited for the work in hand.

The chief difference between this method and Balbach's (U. S. Patent No. 588,524) is, that in the former the electrodes are set at a slight incline from the horizontal, thus permitting solutions of

heavier specific gravity which are formed directly under the anode case to mix more readily with the rest of the electrolyte. In the Thum process a flexible arrangement of cells can be made, whereby the current used may be shunted from the tank house electrolytic circuits. This provides cheap power and does away with the necessity of installing separate generators.

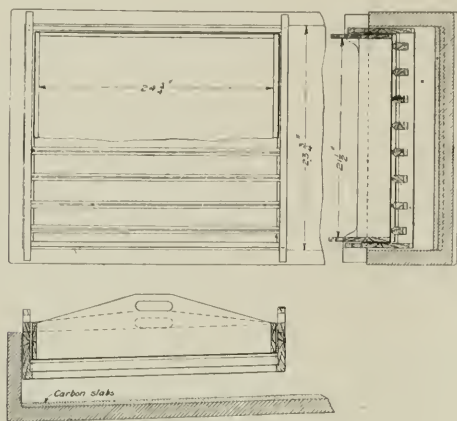


FIG. 7.—DETAILS OF ANODE CASE.

The cells are constructed of white acid-proof chemical stoneware, the bottoms of which are lined with flat slabs of carbon carefully fitted so as to make tight joints. These form the cathodes. Fig. 7 shows details of the anode case and Fig. 5 cross and longitudinal sections of complete cells. Three cells are in parallel, with 3.5 sq. ft. of anode surface per cell. A current density of 40 amperes per sq. ft. is used.

The cathode contact pieces are cast of fine silver and last

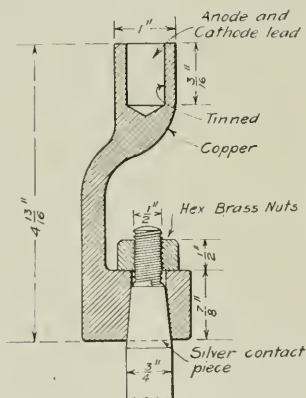


FIG. 8.—CONTACT CONNECTION.

indefinitely. Anode contacts are cast of bullion. These contacts are cast in specially constructed molds, a threaded end being cast directly from the hot metal. In Fig. 8 is shown a detail of the method of connecting silver contact pieces with the busbar which runs overhead.

The general arrangement of plant is such that one aisle is used exclusively for the removal of deposited silver and the adjoining one for the removal of gold mud which remains on

the canvas tray. Deposited silver is scraped from the bottom of the cells, removed in trucks and washed free from the copper silver nitrate electrolyte. A hard rubber pump furnished by the American Hard Rubber Co. handles the wash water and raises it to a storage tank.

After washing and drying, the silver is melted down in a

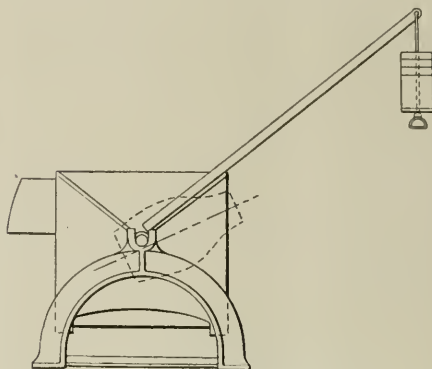


FIG. 9.—FINE SILVER MELTING FURNACE.

tilting crucible furnace, and cast into bars weighing approximately 1000 troy ounces, assaying 999 parts per 1000 fine silver. Fig. 9 shows a view of the furnace used for melting fine silver. The gold mud is removed in trucks, boiled first in nitric, and finally in sulphuric acid. It is melted in an oil-fired crucible furnace made by the Rockwell Engineering Co. In Fig. 10 is shown a view in a sulphuric acid parting plant, which is in sharp contrast with the appearance of an electrolytic parting plant.

Sulphate Building.—Waste solutions from both tank houses are worked up in this department. The free acid is neutralized



FIG. 10.—PRECIPITATING AND WASHING TANKS IN OLD (SULPHURIC ACID) SILVER REFINERY.

by allowing it to flow over shot copper, the copper being exposed alternately to solution and air. After concentration, the solution is run into small tanks where the bluestone crystallizes on lead strips. Fig. 11 is a view of a conical screen used for drying and sizing the crystals.

Foundry Machine Shop and Smithy.—A word should be said, in regard to these departments, which play an important part in the economics of copper refining; the necessity of mak-

ing repairs quickly, and of keeping the mechanical equipment in perfect working condition being of prime importance.

The foundry building is a frame structure 49 ft. x 56 ft., and is equipped with a 6-ton crane. An elevated trestle, which is used for conveying pig iron, coke, etc., connects the railroad track directly with the charging floor of the cupola.

All the iron molds used for casting copper anodes are poured

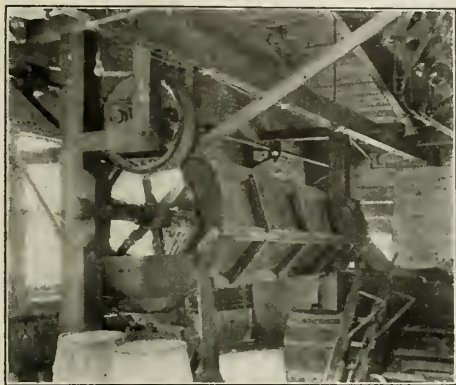


FIG. 11.—SCREEN FOR BLUE VITRIOL.

here, as well as the necessary parts needed for making repairs.

The smithy is a building of brick construction 20 ft. x 67 ft., a large monitor providing ample ventilation. Besides the customary forges, it is equipped with a steam hammer, punch and shears. The machine shop is a combination brick and frame structure 49 ft. x 80 ft. It is painted white inside which, together with the large number of windows, gives a well-lighted interior. The building is divided into three bays, while a crane in the middle bay provides facilities for handling heavy work. The equipment includes a milling machine, 5-ft. radial drill, grinder, 30-in. planer and one 14-in., two 18-in. and one 28-in. lathes.

Hard Spots in Steel Castings, with an Account of Certain Diffusion Phenomena.

BY ARTHUR P. SCOTT.

To the machinist and roll-turner the occurrence of hard spots in castings is not an unusual thing. In the case of cast iron the fault is promptly laid, for the most part, to "chill," which evil, being fairly well understood and having attained a certain traditional dignity, is accepted with more or less of philosophy. Not so with cast steel. To begin with, the trouble is less frequently met with, and so causes more comment; also, it is not so well understood when it does appear, and therefore must be blamed upon some one.

In such event an all too common procedure is this: The foreman of the machine or roll-shop lays a highly generalized complaint before the superintendent. On his next round of the works the latter official, not for cause proven, but on the accepted principle of periodically prodding all and sundry, administers a wiggling to the foundry foreman, who, smarting, visits the plaintiff. In the wordy war which ensues the machinist makes stormy and redundant reference to "segregation," while the foundryman descants upon the futility of tool-steels and tool-dressers, generically and specifically. Follow personalities and an *impasse*, which is eventually relieved by the happy suggestion, "We'll get an analysis on that."

This one remaining stepping stone to retreat with honor is accepted with much solemnity by both combatants, who go their

several ways in peace. (Volumes might be written on "The Laboratory in Diplomacy!") An order presently filters through to the machine where the offending casting is set up, and drillings are obtained and sent to the laboratory "for complete analysis." Quite obviously, a metal that has turned the edge of the best cutting-tool available will not yield to the drill; so that the sample received by the chemist, though taken ever so close to the seat of the difficulty, may be quite irrelevant; but this is of little consequence, seeing that by the time the analysis is reported, the incident has been whirled from view in a cloud of other troubles.

Nevertheless, since after such an interview every right-thinking foreman impartially reprimands all his subordinates, on one pretext or another, and since in an old and well established industry, nearly every difficulty, understood or not, arises simply from someone's failure to take pains, great good accrues from a small evil—good to operation, that is—the net gain in actual knowledge is nil.

A discussion of the extent to which investigation should be encouraged by the modern steelmaker is not within the scope of this paper; suffice it to say that it has been the writer's good fortune to have colleagues who, for the most part, have maintained toward the laboratory an attitude much more encouraging than the one just outlined, and who, while always "out for tonnage," have yet found time to appreciate a crumb of truth for truth's sake. Thus, when a few months ago, in turning up a steel roll in our roll shop, a hard spot was encountered, it was drilled out bodily, and sent to the laboratory for examination. The results of our work in this connection proved to be of considerable interest, and are given here in detail.

The casting in question was for the middle roll of the roughing set of a three-high rail-mill. The steel was tapped from a fifty-ton basic open-hearth furnace into a fifty-ton ladle, whence, after carbon and manganese additions—the former in bags of coke dust, the latter as cold 80 per cent ferromanganese—the necessary

quantity was bottom cast into a swept, silica-washed, dry-sand mold. Near the end of the cast, about twenty pounds of ordinary black thermit was added in the riser. The rough casting weighed approximately 22,000 lbs.

The mold stood in the same pit as the ladle during tapping, and about ten feet away from it; but the top of the former was five feet above the floor from which the furnace helpers made the ladle additions, the brim of the ladle being about three feet below the level of this floor. The tapping temperature was not recorded; the indications are that it was

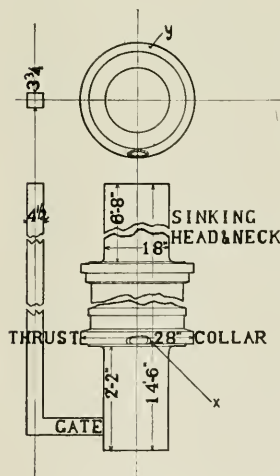


FIG. 1.—CASTING AND HARD SPOT X.

normal. The ladle nozzle was of one and three-quarter inches diameter.

The casting was duly cooled, cleaned, sent to the roll-shop and set up in a lathe, where work proceeded smoothly enough until, in turning up the face of the thrust collar on the bottom end, a spot was encountered, so hard that the best tools available merely jumped over it, leaving barely a scratch behind them. The

hard spot seemed to be associated with a lenticular cavity whose mouth was situated immediately beneath it, and opened on the bottom side of the collar. The somewhat unconventional drawing in Fig. 1 gives a general idea of the casting, and of the location of the hard spot X. The cross section shows a bottom view of the casting minus the gate. Thanks to its position, the defective portion was removed readily, and without in any way damaging the roll, which was finished without further untoward event, and, with the usual intermissions, has been in service ever since.

It is at once apparent that the defect under consideration belongs to the class referred to by Henry D. Hibbard (*Trans. Am. Inst. Min. Eng.*, Vol. 23, p. 626). He says: "There is one of the ills that steel is heir to, that I conceive to be the result of a kind of local segregation, namely, the hard spots sometimes met with near the surface in machinery, both castings and forgings. It is common to ascribe these to particles of spiegel or ferromanganese remaining unmelted or unmixed in the steel. This explanation seems to me to be entirely inadequate. They occur in cases where it is impossible that any of the spiegel could remain unmelted or unmixed. As far as I have been able to observe, they occur in steels cast at too high a temperature.

"My theory for the case is that there is local segregation of the impurities at many places, each of which forms a hard spot near the outside of the mass of pasty steel, each hard spot being a joint where impurities were collected. Gaseous impurities are collected as well, and I have often noticed in forgings which have been insufficiently worked under the hammer, that almost every hard spot had a partially closed up hole, close to, or directly in it."

Now, if we assume the hardness to be due to lack of uniformity in chemical composition, we should very naturally expect to find, from hard spot to surrounding steel, a gradual shading down of the hardness, a gradually decreasing percentage of the hardening element or elements. We should expect this to be true if segregation were the cause of the non-uniformity, and equally so if the distribution had been faulty, because one unconsciously compares the dissolving of a fragment of ferromanganese in molten steel with the dissolving of

a crystal of sugar in a glass of water; one thinks of it as a process of attack, proceeding from surface to center, concurrently with the diffusion of the portion already dissolved through the surrounding liquid. It came, therefore, as a distinct surprise when careful examination—



FIG. 2.—SECTION THROUGH CAVITY.

macroscopic, microscopic and chemical—of the excised portion of our roll revealed the state of affairs shown in Fig. 2.

This is a section of the specimen through the long axis of the cavity and parallel to the long axis of the roll. A is the cavity; the shaded portion, B, is the hard spot, surrounded by C, the normal steel of the roll. We shall consider them separately.

A, the cavity, is lenticular in shape. Its long axis is parallel to the cooling surface of the casting. Its lips are rounded. Its maximum interior dimensions are, roughly, 12x6 centimeters, contracting to 9x4 centimeters at the mouth. It is about 6 centimeters in maximum depth. Its interior surface is of a brownish color, is free from angles, continuous, smooth, free from scale, and concave, suggesting in every way that its gaseous contents have exerted marked pressure upon the surrounding mass during cooling.

Cavities in steel castings are usually described under two heads—shrinkage-cracks and blowholes. Blowholes are subdivided according to their origin as intrinsic or extrinsic to the molten metal, i. e., into 1, those which are caused by gases expelled from the metal on cooling, and 2, those which are due chiefly to imperfect drying or venting of the mold. Each class has its own distinguishing characteristics, and enough has been

said to indicate that the cavity in question is not a shrinkhole, and, further, that it bears little or no resemblance in shape, surface or orientation, to the types of blowhole more usually included in class 1. Indeed, the evidence thus far adduced would point rather to class 2 only. It is somewhat too remarkable that mold defects should so frequently coincide exactly with hard spots, and it seems far saner to assume a casual relationship.

It, in Fig 2, was found to be a manganese-iron-carbon alloy of the following composition: Iron, 84.43; manganese, 11.87; silicon, 1.72; carbon, 1.81; phosphorus, 0.110; sulphur, 0.016.

The alloy constitutes an apparently unbroken envelope about the cavity, and from a maximum thickness of in the vicinity of two centimeters at the lips, tapers away to less than one millimeter at the apex, in a manner that irresistibly suggests the appearance of the bubble one blows in the wall of a glass tube preparatory to perforation. This envelope is, as it were, completely embedded in the steel, from which, though closely adherent to it, without any sign of dehiscence, it is at all points quite distinct. Nowhere is there any perceptible approach to coalescence.

This differentiation is very beautifully shown on polishing, when the sharp dividing line between the gray steel and the bright yellow manganese alloy with its characteristic markings in relief, becomes strikingly apparent. The polishing process, it should be remarked, was an invaluable aid to the preparation of samples for analysis. Our method was to break off a fragment from the main specimen; to grind and polish this fragment on two opposite sides; to take drillings of the steel from the polished surfaces at any desired distance from the dividing line; and, finally, following the line, to grind off all the adherent steel, leaving only the alloy, which could then be beaten up in a "diamond" mortar.

Photomicrograph 1 was prepared from a polished and etched section of the original specimen. The upper portion depicts the steel with some very pretty patches of lamellar pearlite. The lower part is the manganese alloy. There is nothing very striking about the appearance of the latter as here exhibited. Several very beautiful microscopic structures were observed in the alloy, but have been purposely omitted, the object of the photograph being merely to illustrate the line of partition.

The chemical composition of our alloy, taken in conjunction with its sharp differentiation from the steel, was somewhat puzzling. Segregation as a possible cause of the phenomenon—that is, segregation in the commonly accepted sense of the term—is entirely out of the question; more especially since, as is well known, and as has been repeatedly proven true in the writer's experience, manganese, under ordinary conditions, shows less tendency in this direction than any of the other elements commonly component of steel.

On the other hand, it is definitely known that when the roll was cast, an 80.00 per cent ferro was the only manganese alloy in the mill; and every lot of ferro ever used there conformed fairly closely to the average analysis quoted below. The only other manganese alloys that had at any time been used in the mill were spiegel and silicospiegel, and they were always separately stocked.

In any case, admitting the remote possibility that some remaining lump of these poorer alloys had become mixed with the ferro that was employed for this particular casting, we are no nearer a satisfactory explanation than we were before, as will appear from the following table of average analyses taken from our stock book:

	TABLE I.			
	Carbon.	Manganese.	Silicon.	Phosphorus.
Ferromanganese	6.60	79.87	.56	.250
Spiegel	4.43	21.45	1.60	.104
Silicospiegel		21.44	8.82	...

To none of these does our alloy correspond, and the only justifiable inference appears to be that it is an alteration product, probably of ferromanganese. One point more—it is unlikely, from the relative positions of mold and ladle, that any frag-

ment of ferromanganese intended for the ladle, could accidentally have fallen into the mold. We, therefore, provisionally conclude that it was added to the ladle in the usual way, but failed of perfect distribution.

NO. 1 $\times 100$ D.NO. 2 $\times 100$ D.

MICROPHOTOGRAPHS NOS. 1 AND 2.

C. Analyses were made of nine separate samples of drillings of the steel proper, C (Fig. 2), taken from as many different holes. Hole No. 1 was $\frac{1}{2}$ inch in diameter, and drilled close to the envelope B. Holes 2 to 8 inclusive, were $\frac{3}{8}$ inch in diameter, and were drilled at varying distances from B, but all within ten centimeters of it. Hole No. 9 was $\frac{7}{8}$ inch in diameter, and was drilled from the original roll at the point Y (See cross-section Fig. 1), diametrically opposite to the position of the blowhole. Note the analytical results:

TABLE II.

Drill-Hole No.	Carbon.*	Silicon.	Phosphorus.	Sulphur.	Manganese.
1.	.57	.135	.035	.033	.85
2.	.54	...	...	...	.86
3.	.52	...	...	...	.86
4.	.53	...	...	...	.84
5.	.53	...	...	...	.84
6.	.53	...	...	...	.86
7.	.52	...	...	...	.84
8.	.54	.147	.031	.029	.84
9.	.56	.170	.030	.030	.88

* Determined by combustion.

Clearly, if the ferro have lost manganese, phosphorus and carbon, the steel surrounding the residue was not thereby the gainer.

At this point in the investigation, it became apparent that our specimen must be regarded as an exception unless we could multiply examples, or else reproduce the phenomenon at will. Following the latter course, we made numerous experiments with fragments of ferromanganese and themit iron, with no result other than a number of manganiferous nodules of most uncompromising hardness, that left no doubt in one's mind as to the thoroughgoing nature of the diffusion that had there transpired. After equally unsuccessful endeavors in other directions, we tried a method which, after a short explanatory note, we shall outline.

From every heat of steel that is tapped in an open-hearth mill, a test ingot is taken from the ladle at the pouring platform, usually, when about half of the heat has been teemed; and a convenient mode of taking it, is to hold the small iron test-mold on a peel under the nozzle of the ladle, while the leverman allows a small stream of the steel to run into it.

The resultant ingot is readily knocked out of the mold, and, when properly cooled, is drilled for analysis. The shape and dimensions of the test ingot used in our laboratory are shown in Fig. 3. Such an ingot weighs about 1 kilogram. Blowholes

and shrinkage, it is scarcely necessary to mention, are responsible for the difference between this figure and the calculated weight.

Our final attempt was as follows: Having set a small pyramid of ferromanganese in the center of the bottom of one of the little test molds, we filled the latter with molten rail-steel during the teeming of a heat, in the manner just described for the usual ladle test. The test ingot thus obtained, on removal from the mold, showed plainly on its bottom the outlines of the base of the pyramid embedded in the steel, and apparently unaltered.

With the aid of a hack-saw and wedge, a slice was cut from the center of the ingot, through the lines *l* and *m*, Fig. 3, followed by a vertical bisection of the slice, at right angles to these cuts, so that an approximate bisection of the pyramid was obtained. To a height of perhaps 0.4 cm. above the bottom of the mold the ferro was unchanged, but above this there was a sharp alteration in appearance.

The pyramid seemed to have materially increased in bulk, and a tiny vermiform blowhole had developed about its central axis. Polishing revealed the fact that it was everywhere quite distinct from the surrounding steel, and its manganese content was found to be only 32.86 per cent. All this is clearly shown

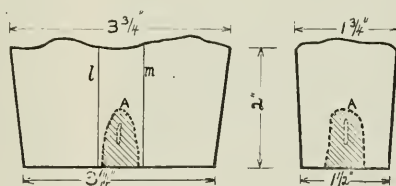


FIG. 3.—TEST INGOT.

in Fig. 3, where the shaded portion A is the ferro. Photomicrograph 2, taken near the apex A, shows the contact line.

The ferro used in this experiment had been chipped from a lump weighing about ten pounds. This lump was now broken wholly into fragments, a number of which were selected at random for the preparation of further pyramids, while the remainder were crushed down for analytical purposes; and, with the light so far vouchsafed, a series of four tests was prepared from the same number of heats of rail-steel, and as many pyramids from the original lump of ferro.

In each case, the regular ladle test—which was taken immediately before our special manganese test—was preserved for comparative examination. Each manganese test was now opened up in the manner described above. A section showing the dividing line between ferro and steel was prepared for

microscopic examination; a portion of the altered ferro was carefully isolated for analysis, and, to the same end, drillings of the steel were taken, as close as might be to the dividing line. The corresponding ladle test was sawn in two, and drillings taken from a corresponding point therein.

A synopsis of the analytical results from this series appears in table III, in which the heats have been arbitrarily num-

These all faithfully reproduced the features of Fig. 3, already outlined, for the first experiment, viz., 1, the base of the pyramid was always unaltered—a natural consequence of the chilling effect of the mold; 2, the upper and greater part of the pyramid had increased in bulk; 3, it had maintained at all points the sharp division between itself and the steel.

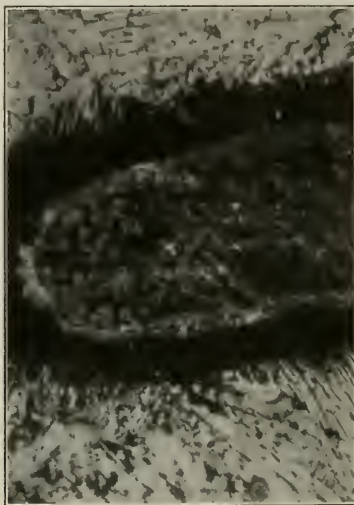
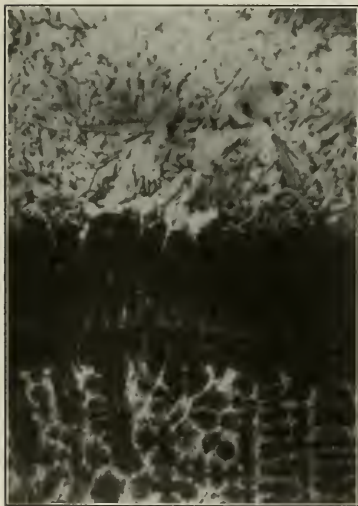
Photomicrograph 3 of a section from the apex of the pyramid in heat No. 29 may be considered, equally with No. 2 as generally typical of all three.

Small, centrally located blowholes were always in evidence—either one vermiform cavity, or a row of spherical ones. In addition to these characteristics, the hacksaw was stopped in nearly every cut by globules of the manganese alloy, that had evidently been thrown off from the main body. These globules, or shot, were quite distinct from the steel, and were all found within 1 cm. of the skin of the top and sides of the ingot.

In view of the great degree of similarity exhibited by the three heats, both in their physical features and in their chemical histories, it will simplify matters, without being in any way misleading, to consider an average of the values recorded for them in Table III.

It is obvious that the composition of the ferro has in every case undergone grave alteration, and that in the same direction. It is equally obvious that under the conditions of the experiments, this alteration must have come about in one of three ways, viz., 1, by the outward migration of carbon, phosphorus and manganese from ferro to steel without any immigration of iron from steel to ferro; 2, by emigration of carbon, phosphorus and manganese, with simultaneous immigration of iron; 3, by an immigration of iron from steel to ferro unaccompanied by any passage of carbon, phosphorus or manganese in the opposite direction, i. e., from ferro to steel.

Case 1.—Emigration only. Let us assume that on coming in contact with the walls of the mold, the steel chills to a depth of 0.4 cm.—a figure which will be quite near the truth—before the ferro becomes molten and active. This gives us a skull, weighing about 450 g., which can take no part in any mold

NO. 3 $\times$ 100 D.NO. 4 $\times$ 100 D.NO. 5 $\times$ 100 D.NO. 6 $\times$ 100 D.

MICROPHOTOGRAPHS NOS. 3, 4, 5 AND 6.

bered 20, 21, 22 and 23. In the steel analysis columns, A refers to the drillings from the regular test, and B to those from the special test. (See Table III on page 285.)

For a reason which will appear, we shall for the moment consider only heats No. 20, 21 and 22.

TABLE III.

Heat number.	Weight of test, 1180 g.	Weight of Ferro, 20.4 g.	Altered Ferro.			Steel, center drillings.		
			Total C.	P.	Mn.	C.	P.	Mn.
20	995 g.	19.5 g.	3.41	.178	37.45	A...57	.039	.89
21	995 g.	19.5 g.	3.69	.172	43.28	B...57	.040	.93
22	1370 g.	31.5 g.	4.42	.186	49.44	A...62	.043	.103
						B...62	.043	.108
						A...67	.032	.85
						B...62	.028	.107
Average of 20.								
21 & 22	1182 g.	23.8 g.	3.84	.179	43.39	A...62	.038	.92
23	1120 g.	13.8 g.	...	...	...	B...60	.037	.103
						A...54	.040	.92
						B...58	...	1.01
						B2...59	...	1.01
Original Ferro	...	...	6.45	.288	77.72			

reaction. Five grams would be a liberal estimate of the amount of ferro remaining unaltered in the base of the pyramid.

Now, considering for convenience that the ferro consists only of carbon, iron and manganese, at the beginning of the mold reaction we have: skull, 450.0 g.; active ferro, 18.8 g.; active steel, 713.2 g.

At the end of the reaction we should have our 450.0 g. of unaltered steel, a very small bulk of altered ferro—about 5.6 g.—and the balance of the test would be steel, enriched in carbon and manganese to the extent of .14 and 1.70 per cent respectively, which enrichment, plus the original content, would yield a steel containing .76 per cent of carbon, and 2.64 per cent of manganese. Case I evidently does not apply.

Case II.—Engration and Immigration. In our experiments, the ferro-manganese, once it has attained the temperature of the molten steel is, on account of its lower melting point (see Table IV), characterized by greater mobility than the latter. Its molecules are more active than are those of the steel. Before the ferro has reached this stage, there is a period during which the steel will have the advantage in this respect; but it is probable that such period is of relatively short duration; and, upon the whole, from this point of view, it would be expected that the outward travel of the carbon, phosphorus and manganese would proceed more rapidly than the passage of the iron inwards. Let us suppose, however, that the rate of travel is the same for all the elements in both directions.

We find, following the line of calculation employed in Case 1, that we should have left an altered pyramid of approximately the same weight as the one we started out with, and a matrix of steel enriched to 0.69 per cent of carbon and 1.82 per cent of manganese. No such enrichment has occurred. It appears that the average B carbon is actually slightly lower than the A carbon, and that the manganese figures in 20 B and 21 B are only 0.04 and 0.05 per cent greater, respectively, than the A values. Indeed it is only the general trend of the average that entitles these small majorities to consideration.

Case III.—Here we look upon the alteration that has taken place in the ferro as a simple process of dilution; and we shall expect to find: 1, That the pyramid has increased in bulk; 2, that the surrounding steel, other causes apart, has suffered no chemical alteration other than a slight concentration due to loss of iron; 3, that the ratio of percentage in altered ferro to percentage in original ferro is the same for all the elements except iron. The ratios in the present case, calculated from the averages in Table III are: For carbon, 0.595; for phosphorus, 0.621; and for manganese, 0.558. In each of these three respects, Case III appears to fit the observed facts with remarkable closeness. The slight discrepancies find their explanation in what follows.

The evidence so far in hand would lead, therefore, to the supposition that when molten ferro comes in contact with molten steel, there sets in, from steel to ferro, a migration of iron molecules which continues, if uninterrupted by solidification, until both metals are of the same composition, and that then, and only then, merging of the two is effected and the dividing line disappears, though it may become imperceptible by any means at our disposal, before this stage has actually been reached.

It has been remarked that in our tests, globules were thrown off from the main body of ferro. There were probably many more of these little planets than chance to be in the path of the saw in the particular cuts that were made. It is also exceedingly likely that some of the globules were so tiny that they were speedily reduced to the composition of the surrounding steel, becoming a part of the latter and raising its manganese content.

This would account for the few points of increase in the B lines of Table III. No one who is in the least familiar with the idiosyncrasies of steel ingots—large or small—will invest with significance the trifling carbon discrepancies noticeable in the steel figures in this table.

Further, at any instant in such a process of "infusion" as we are picturing, the outer skin of the pyramid contains more iron than the central portions. In order, therefore, to get a perfectly "sound" sample of the altered pyramid for analysis, it would be essential to secure every particle of it, reduce it to fine powder and mix it thoroughly. In point of fact one considered oneself fortunate if one managed safely to isolate barely enough for the necessary determinations.

Moreover, the material is to a certain extent malleable, and cannot be pulverized nor mixed at all thoroughly; so that, in view of everything, the figures for the carbon, phosphorus and manganese ratios, given above, are really wonderfully close, and may safely be considered to represent the same value.

As has already been implied, heat No. 23 behaved differently from the others. In this case, the pyramid of ferro was raised bodily by the incoming stream of steel, floated immediately up to the surface of the test and, melting, spread over the entire top as a crust, quite distinct from the steel, and visible as such in the cold ingot, in which also were embedded a number of distinct globules just beneath the crust. Analyses 23 B 1 and 23 B 2—Table III—are of drillings taken from the steel in the neighborhood of the globules, and from the heart of the test, respectively. These figures are readily explained by which has been said of heats 20, 21 and 22.

It will be convenient at this stage to set down such melting points of iron-manganese alloys, with or without carbon, as are at present available to the writer. They are introduced—without comment—along with certain other melting points which have a bearing on the matter in hand.

TABLE IV.

	Total C.	Comb. C.	Graph.	Si.	S.	P.	Mn.	Fe.	Solid. Pt.	Meltg. pt., deg. C.
Ferromang ¹	5.10	.71	.65	...	...	...	80.96	13.16	210	...
" "	5.00	...	.43	.11	.48.95	45.51	48.95	14.51	1145	...
" "	4.86	...	.80	.098	16.97	77.51	1083	...	...	...
" "	6.56	.120	.56	Ir.	30	82.36	1000	1230	...	...
" "	...	...	...	...	10.00	...	...	...	...	...
" "	...	...	...	...	26.00	...	...	...	1483	...
" "	...	...	...	...	30.00	...	...	...	1442	...
" "	...	...	...	...	40.00	...	...	...	1360	...
" "	...	...	...	...	50.00	...	...	...	1310	...
" "	...	...	...	...	60.00	...	...	...	1288	...
" "	...	...	...	...	70.00	...	...	...	1275	...
" "	...	...	...	...	80.00	...	...	...	1260	...
" "	...	...	...	...	90.00	...	...	...	1250	...
" "	...	...	...	...	99.40	...	...	...	1245	...
White iron ⁴ ...	3.85	Ir.	.29	.03	.02	.15	...	1065	1030	1065
Gray iron ⁵ ...	3.50	...	1.75	...	.50	...	...	...	...	1220
Soft steel ⁶ ...	...	...	...	...	.30	...	...	...	...	1410
Hard steel ⁶ ...	...	...	.90	...	...	.10	...	...	...	1410

¹ Jour. Iron & Steel Inst. 1900 II 343, from Osmond & Werth, Ann. des Mines, July-Aug., 1888.

² Roberts & Wraight, Jour. Iron & Steel Inst. 1906 II 235.

³ This Journal, IV, 190, from Levin & Tamman, Metallurgie, Jan. 22, 1966

⁴ Royston, Jour. Iron & Steel Inst., 1897 I 167.

⁵ Hofman, "Iron & Steel," from Le Chatelier, Comptes Rendus

⁶ Cremer & Bicknell, from Le Chatelier.

Cramer & Dickson, from 2000 onwards.

The whole process of infusion, as we have portrayed it, must

be conceived to be quite rapid, inasmuch as the phenomena de-

be conceived to be quite rapid, inasmuch as the phenomena described have occupied only the few moments elapsing between

described have occupied only the few moments elapsing between the pouring of the test and its solidification. We have seen

the pouring of the test and its solidification. We have seen that, by itself, it does not speed the reaction, but, on the other

that when thermit was used, the reaction, always supposing it

to have been of the same nature, was practically instantaneous,

on account, doubtless, of the very high temperature of the

thermit iron. It was anticipated that by repeating the pyramid test with soft steel instead of rail steel, an intermediate stage might be arrived at.

Two such tests were accordingly poured, which we shall call heats 24 and 25. Heat 24 developed the structure shown in Fig. 4. Where the pyramid had been, appeared a cavity, considerably larger than the pyramid, opening on the bottom of the test. This cavity, A, Fig. 4, is enveloped by a distinct sac of manganese alloy—shown in the drawing by dotted lines—which was found by analysis to contain 26.30 per cent of manganese.

Almost the entire upper part of the ingot is occupied by one large cavity, B, Fig. 4, which, like A, is enveloped by a



FIG. 4.—STRUCTURE OF HEAT 24.

distinct manganese sac. A portion of the B wall was found to contain 34.33 per cent Mn; but it should be mentioned that the B sample was rather a globule adherent to the sac wall, than a part of the wall proper, and that this doubtless accounts for the higher Mn content. We should naturally expect the B wall to have undergone more alteration than the A wall.

Unfortunately, the difficulty of separating the thinner portions of the alloy from adherent steel prevented a more exhaustive examination. It was readily notable, that the walls of A and B exhibited none of the superficial characteristics of ordinary blowholes, but answered exactly to the description given above for A, Fig. 2.

Besides A and B, there appeared at C, Fig. 4, a lenticular body of manganese alloy parallel to the skin of the ingot, and about 0.5 cm. away from it, which offshoot showed at its center, a small vermiform cavity similar to the one seen in A, Fig. 3.

Several globules were also found at various points, but always next to the skin. One of these is sketched at D, Fig. 4. The

way our former deductions, but shed light on the formation of the blowhole in the original roll. It would appear that a part of the gases that are commonly in solution or combination in molten steel, has migrated with the iron molecules into the manganiferous body. Their tendency in this direction was foreshadowed by the small blowholes observed in the centers of the first four pyramids, but has only been convincingly demonstrated in the last two cases, doubtless in some measure on account of the higher gaseous content of soft steel, as well as because of the higher temperature.

This, then, is probably what occurs when soft steel is poured upon a fragment of ferro manganese—the ferro fuses, and an influx of iron and gas molecules promptly sets in from all sides. The gas, when it reaches the molten ferro, is thrown out of solution because of the notably lower solvent power of the manganese alloy for gases.

Such oxygen as may be present combines with the carbon of the ferro, forming CO. The pyramid, perforce, increases in size. In the meantime its extreme outside layer, on account of its higher iron content, is at any moment nearer its solidifying point than the interior, and, as cooling and dilution progress, the pyramid presently becomes a cyst, with a more or less rigid envelope, and a fluid interior.

At this stage, the envelope cannot expand rapidly enough to meet the demands of its ever-increasing gaseous and liquid contents, which finally rupture their sac at the apex, which is the hottest and weakest point. This breakout is also assisted by the relatively higher mobility and lower gravity of the sac contents, which by virtue of these attributes take an outward and upward direction and rush to the top and sides of the ingot, arranging themselves parallel, as to their long axes, to the cooling surface.

The portions which station themselves at the sides are soon imprisoned in the cooling steel and rendered inactive. The main body, however, locates itself in the middle top of the ingot, which, being the last to solidify, affords ample time to its tenant for the reception of iron and gas molecules from the surrounding mass. The resulting bubble, finding no weak spots to break through, expands in loco till checked by solidification.

(To be concluded.)

Thermit

We have referred before to the injurious influences of nitrogen on iron and steel and the possibility of removing nitrogen from steel by introducing titanium into the ladle. In No. 2 of *Reactions*, published by the Goldschmidt Thermit Co., the following analyses are given on the effect of the titanium thermit reaction on the sulphur content: they also show that only traces of the titanium were absorbed by the metal:

Cast iron before treatment, 0.36 Mn, 0.19 S; after treatment, 0.30 Mn, 0.09 S, traces Ti. Another analysis gave before treatment, 0.66 Mn, 0.09 S; after treatment, 0.64 Mn, 0.07 S, traces Ti.

Results of mechanical tests are also given, showing the increase in strength of metal treated with titanium thermit.

Besides the very interesting article of Dr. Hans Goldschmidt on calcium silicide, a purifier for steel (published in our last issue, page 244) the same issue of *Reactions* contains illustrated articles on the welding of rails under New York City traffic conditions, pipe welding experiences, various thermit repairs, etc.

An article by Mr. G. E. Pellisier discusses blow-holes in thermit welds, their cause and prevention and shows that the secret of success lies in proper preheating of the pieces to be welded. "The secret of success is to have the parts to be welded at a bright red heat, when the thermit steel is poured, provide a good sink head, have the thermit and additions thoroughly mixed and take care not to tap the crucible until the reaction is thoroughly completed."

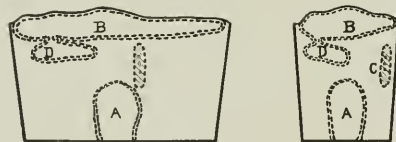


FIG. 5.—HEAT 25.

small spur attached to this globule is the subject of photomicrograph 4, of which more anon. Center drillings of the steel from the regular ladle test and from the pyramid test of heat No. 24 showed:

Heat No. 24	C.	P.	Mn.
Regular test.....	.18	.043	.36
Pyramid test.....	.20	.044	.36

The internal arrangement of the ingot obtained from heat No. 25, is sketched in Fig. 5, and closely resembles No. 24 in every particular, except that in Fig. 5 the upper wall of B constitutes the top crust of the ingot. Further, this wall is extended downwards to cover a short canal, and a third blowhole D, to which the canal leads up. Shot are also freely in evidence.

In this instance no reliable drillings could be obtained from the steel, because of the proximity to one another of A, B, and D, and because of the shot. Also the sac walls were too thin to isolate satisfactorily.

The last two experiments thus not only confirm in every

Separating Appliances—II.

BY OSKAR NAGEL, PH.D.

Presses.

Another appliance for separating solids from liquids by means of pressure is the press.

The simplest type which can be used for this purpose is the screw press (Fig. 1). The material to be dried is filled into bags or wrapped up in cloths and then put into the press. The various bags, etc., are separated from each other by means of metallic or wooden plates.

For chemical works the hydraulic presses are of greatest importance, since their requirements as to power and attendance are small.

The construction of the hydraulic press is based upon the principle of the uniformity of pressure in liquids contained in closed vessels. The press consists of two separate parts—the press proper and the press pump. The press proper is illustrated in Fig. 2, showing the piston moving in its cylinder, the head-plate, and the columns connecting the base with the head-plate.

The press pump is a plunger pump provided with automatic relief set to a certain pressure, which naturally varies according to the nature of the material to be pressed.

The pressure produced by the press pump is transmitted from the liquid of the pump (water, glycerine or a mixture of both)

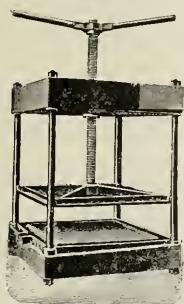


FIG. 1.—SCREW PRESS.

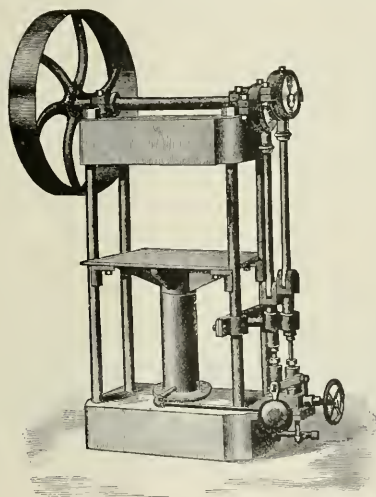


FIG. 2.—HYDRAULIC PRESS.

to the liquid in the cylinder of the press, whereby the same pressure is exerted upon the unit of area of the piston of the press, as upon the unit of area of the piston of the pump.

The material to be pressed is handled in the same manner as with a screw press. If the pressing is to be performed at a high temperature, the plates separating the layers (cakes) have to be heated by steam. One press pump is sufficient for several presses.

Hydraulic presses are built by the Watson-Stillman Co., New York; R. D. Wood & Co., Philadelphia, and The Hydraulic Press Manufacturing Co., Mt. Gilead, Ohio.

Other Filtering Appliances.

For filtering thick and pastry masses, vacuum filters (Fig. 3) are used, the vacuum being produced by means of a steam jet blower or a vacuum pump. For acids these apparatus are made of lead or of clay.

M. Garros recommends asbestos-porcelain as filtering mass for strong acids. This material is prepared by grinding asbestos to a fine powder and washing the latter first with muriatic acid and then with pure water. The plastic mass so obtained is burned at about 1600° C. and shows after cooling such fine pores that it can be used successfully as filtering material.

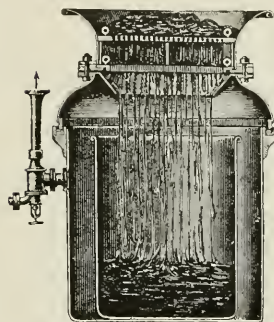


FIG. 3.—VACUUM FILTER.

Another method of separating solids and liquids is the application of sand and other filters. For this purpose basins are built in which layers of pebble, gravel and sand are provided, the latter being supported by

perforated plates. The water so to be filtered enters on top, flows through the three layers and finally reaches, in a pure state, the pipe line provided below the perforated plates.

The operation of these filters is rather slow, gravity being the only acting force. If a quicker method is desired, pressure has to be applied. Such pressure filters will be described in an article on the purification of boiler water.

If the water is only cloudy and its filtration meets with great difficulties the following device is to be recommended (Fig. 4).

The reservoir H contains the water to be filtered; tank M contains a thin pulp of cellulose or fibrous asbestos with water.

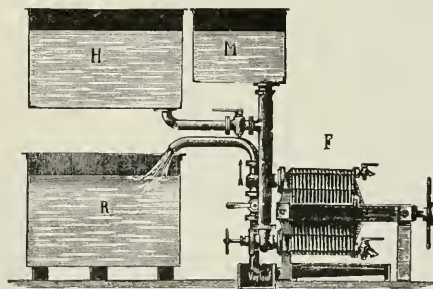


FIG. 4.—FILTERING DEVICE.

F is the filtering apparatus proper and the purified water runs off into R. F is built like a filterpress and contains a number of chambers, the walls being formed by metallic sieves.

At first the thin pulp or paste is passed (from M) into the filter F, where it is uniformly divided. The arrangement is somewhat similar to the three-chamber press mentioned in a previous article. The water from H is then allowed to run through this filtering mass and flows into tank R. When the filtering mass becomes inactive, it has so to be removed and washed, before being put to use again.

For the treatment of slimes the filters built by the Blaisdell Company, of Los Angeles, Cal.; The Kelly Filter Press Co., of Salt Lake City, Utah, and The Butters Patent Vacuum Filter Company, Inc., of San Francisco, Cal., are used.

The Blaisdell pressure filter (Fig. 5 and 6) contains a series of filter leaves, depending in number and size upon the capacity desired; a pressure cylinder and pumps for vacuum, slimes, water and solution, with pipes and valves.

With a pressure of 25 to 50 pounds per square inch in the pressure cylinder, the clear water or solution is rapidly forced into the interior of the filter leaves, and out through the discharge pipes to the water or solution tanks, the slime remaining as a cake on the outside of the filter leaves.

This process is continuous and is carried on without interrupting the flow of slime to the pressure cylinder. As soon as a cake of sufficient thickness is formed, clear water under a greater pressure than exists within the cylinder is admitted to the interior of the leaves in groups. This excess of pressure causes the cake on that particular group of leaves to fall through the slime to the bottom of the cylinder. The thickened material accumulating on the bottom of the cylinder is discharged from time to time.

The Kelly filter (Fig. 7) consists of a tank in which a carriage runs on tracks carrying the filters. Whenever the filters are heavily charged with separated solid material, and it is desired to remove the collected solid material from the sides of the filter frames, the carriage is run out of the tank on to an exterior trackway. (See also this journal, Vol. V, p. 508, and Vol. VI, p. 163.)

The Butters filter was described in detail in the March issue of *ELECTROCHEMICAL AND METALLURGICAL INDUSTRY*, Vol. V. p. 88. (See also the account of a recent patent of Mr. Butters, this journal, Vol. VI, p. 120.)

Separation by Crystallization, Extraction and Sublimation.

Crystallization.—For separating a dissolved salt from its solvent or from a mixed solution, various methods can be used. If the substances have the property of being precipitated by concentration—soda, etc.—the solutions are evaporated and the separating crystals are continuously removed, for which pur-

pose the Thelenpan, which will be described in another article, is exceedingly well adapted.

There are cases (Glauber's salt, etc.) where no direct precipitate is obtained during evaporation, but where it is necessary to cool the solution. The solid substances are then allowed to separate by crystallization in suitable vessels.

For effecting a uniform crystallization throughout the liquor, hooks made of steel or copper wire are suspended into the same, by means of which the crystals can be easily lifted out of the liquor.

If no hooks are used, the crystals formed fall to the bottom and the mother-lye has then to be syphoned off. If crystals

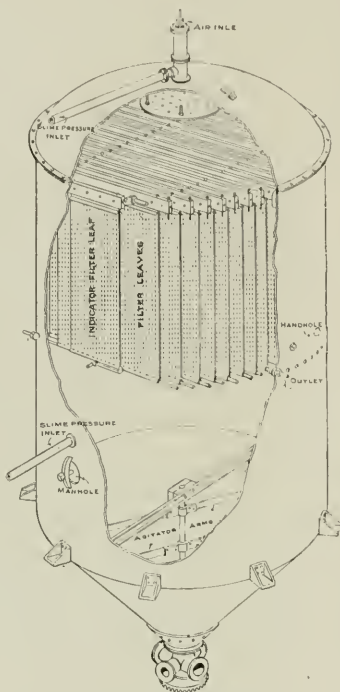


FIG. 5.—PRESSURE FILTER.

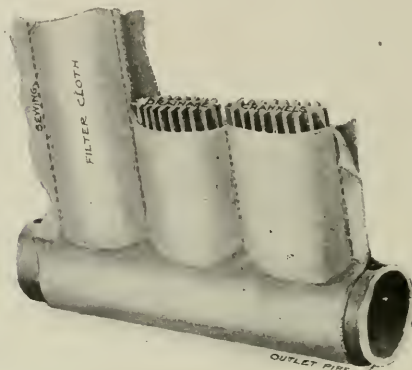


FIG. 6.—PRESSURE FILTER.

deposit on the walls of the vessel, they can be knocked off and removed by means of perforated spoons. Or, perforated pots are put into the vessel and the mother-lye entering the pots is syphoned off.

Extraction is used for separating the soluble components from a partly soluble substance. The high pressure frequently applied during extraction is produced by either steam or compressed air, depending upon the nature of the material to be treated.

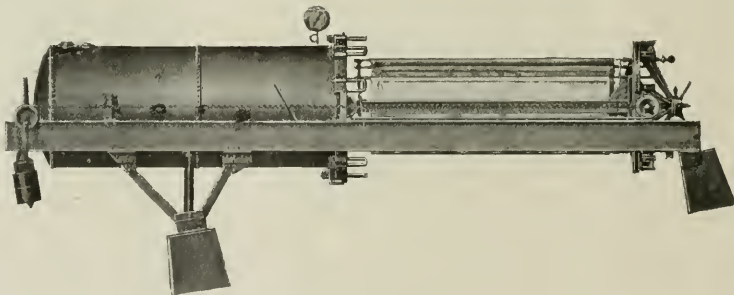


FIG. 7.—FILTER PRESS.

An extractor for dyewood, tanbark, etc., is shown in Fig. 8. The extractor is a vertical cylinder, provided with a charging and discharging opening, water and steam inlet and solution outlet. The armature consists of a manometer, thermometer and two test cocks.

If several of these apparatus are connected to a battery the connection is made in such a manner (see Fig. 8) that the final

solution of the first apparatus is utilized for eluting the fresh charge of the second apparatus, whereby the concentration of the solutions is increased. The apparatus to be discharged first gets the fresh water, while the more concentrated solution is taken from the apparatus charged with fresh material.

An apparatus for extracting at high temperature and ordinary pressure fats, oils, rosins, etc., by using benzine, bisulphide of

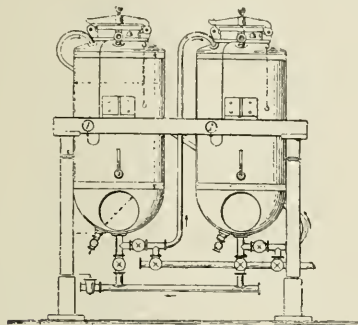


FIG. 8.—EXTRACTOR.

carbon, alcohol, etc., as solvents, is built by Josef Merz in Brünn (Austria).

The vessel C (Fig. 9) contains at the bottom a steam coil Q, and above it a reservoir L, which is charged through the manhole *d* with the material to be extracted. From the reservoir V, which is combined with the cooler R, the solvent is allowed to flow into L. As soon as the level of the solvent exceeds the

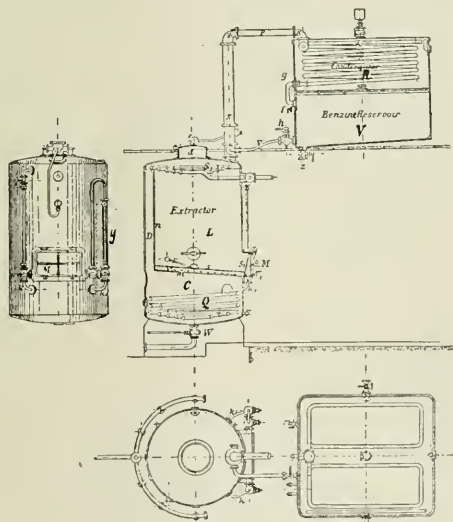


FIG. 9.—EXTRACTION APPARATUS.

height of syphon *y*, it is drawn into C. In C the solution is evaporated, the vapors rise along the wall of reservoir L, heating its content and finally arrive at coil S, where they are condensed. The warm liquid "rains" back into L and after rising to the height of the syphon, again goes into C.

This automatic circulation is interrupted, when a sample taken as M shows that the extraction is finished. The cooling water (in S) is stopped, the vapors of the solution flowing from

L into C travel to cooler R and are collected as liquid in reservoir V. The last traces of the solvent are removed from the extract and the spent material by means of direct steam.

The extract is discharged through W and the extractor L at M. This apparatus permits intermittent and continuous ex-

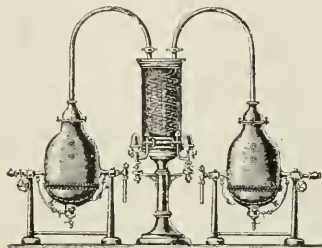


FIG. 10.—EXTRACTION APPARATUS.

traction. In the latter case the flow of the fat-solution is so regulated that the level of liquid in L is kept constant by the evaporated and regenerated solvent.

This universal extractor affords perfect safety against ignition and explosion, insuring a minimum consumption of the solvent, simple and economical operation and absence of odors.

A twin apparatus for extracting etheric oils is shown in Fig. 10. It consists of two stills which can be heated by leading steam into the "false bottom" or by direct steam led into the interior of the apparatus.

The solid substances to be treated in the extraction apparatus rest upon a perforated plate.

After charging the apparatus with the solid substances and the extracting liquid, the steam valve is opened, whereby the extracting liquid is vaporized. This vapor travels through the substance, rises upward along the dissolved components and enters the cooler. When leaving the cooler it is tested as to its "extract" contents, and recharged until it shows the concentration required.

Sublimation.—This process, in which gaseous distillates are directly solidified without passing through the liquid stage, is employed in the case of iodine, salamoniac and camphor. Fig. 11 shows a simple apparatus for subliming camphor. The refined camphor forms a solid cake at the top of the vessel, while the impurities remain as a residue on the bottom.

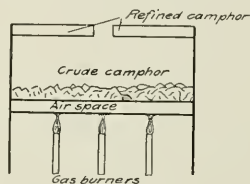


FIG. 11.—REFINING CAMPHOR.

Separation by Settling and Freezing.

Liquids of different specific gravity which do not mix can be separated by allowing the heavier liquid to settle. The apparatus (Fig. 12) has near the bottom an opening, to which an S-shaped overflow pipe is connected. If a layer of oil is floating upon the water, only the water will flow through this pipe. If the oil is to be collected the water is let off until its surface is on the same level as the cock at the left side. Then the oil is allowed to run off through the cock.

Sometimes liquids are separated by cooling and removing the frozen part from the liquid (Lunge's monohydrate process).

Separation by evaporation and distillation will be described in another article.

Mechanical Separation of Solids.

The separation of substances according to their size ("sizing") is a matter of great importance in metallurgy and is generally performed by means of screens.

Fig. 13 shows an arrangement of three revolving screens, in which either perforated metal or wire cloth may be used. Bevel gearing is shown driving the first screen, which communicates motion by spur wheels to successive screens having finer perforations or meshes, and being placed at lower levels. In concentrating works, sets of four or more such screens are usually employed.

The first screen separates out all pieces too large for the ore treatment processes so that they may be returned to the crushing machinery. The remainder passes through the perforations of the first screen, and is conveyed to the second screen, and so on through the set, each screen furnishing a product sized between the limits of the size of its own perforations and the perforations of the preceding screens.

For separating coarse from fine substances without the use of sieves, by means of an air current, "separators" are used.

In the separator of Mumfords and Moodie (Fig. 14) a ventilator *E* is provided upon the vertical shaft *E*₂. The latter carries also the distributing plate *S*, the object of which, as the name implies, is to distribute over its periphery the material to be separated. By a system of rings, disks and cones the air drawn in by the ventilator is forced through the material which is constantly falling down in the shape of a bell. The air current carries the fine, dusty particles along and enters the ventilator, the mixture being thrown against the wall of the cylindrical tank *A*. The fine particles are carried to the bottom by the air current. The coarse parts not carried along by the air current fall into the interior cone *B* and may be retransported to the mill (through pipe *a*), while the separated fine product falls into the space between housing *A* and cone *B* and is removed from here by hand or a screw conveyor.

The jigs and magnetic separators will be described in another article.

Foundrymen's Convention.—The convention of the American Foundrymen's Association and its associated societies, held in Toronto, Canada, from June 8 to 12, proved a success beyond all expectations. The registration on the last day passed

Annual Meeting of the Iron and Steel Institute.

The thirty-ninth annual general meeting of the Iron and Steel Institute was held in London on May 14 and 15, the president, Sir Hugh Bell, being in charge.

From the report of the council it may be mentioned that the total membership has increased from 1500 in 1898 to 2100 in 1908. The Bessener gold medal was presented this year to Mr. Benjamin Talbot, Middlesborough, while the Carnegie gold medal for research was awarded to Dr. C. A. F. Benedicks, of the University of Upsala, Sweden.

In the following we give abstracts of the progress presented at the meeting:

Cast Iron in Chemical Plant.

A paper by Mr. T. J. R. CARULLA (Derby) discusses the use of cast iron in the construction of chemical plant.

Wrought iron and its modern substitute, mild steel, do not need lengthy attention. The use made of the material for gas holders and similar vessels need not be dwelt upon, and its value for bolts, bands, stays and beams, when these can be painted or tarred to prevent corrosion, cannot be overlooked.

But here the surprising thing happens, that although so easily corroded, tanks can be made of this material that will carry strong sulphuric acid for years without damage being done to them. The only care necessary is that no water be admitted into the tank after use, when, of course, if left in a weak acid solution would be formed and rapid corrosion ensue. Inattention to this requirement will certainly cause the destruction of a tank.

Cast iron, the main object of the paper of Mr. Carulla, furnishes a substance that the chemical manufacturer could ill afford to be without, but which, in consequence of its varied composition and uncertain properties, is most difficult to classify. The consequence is that there are firms who possess experience and special knowledge of the use of particular brands for certain purposes that are unknown to the trade in general.

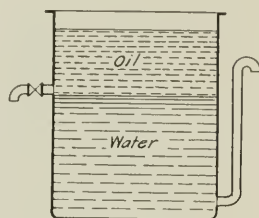


FIG. 12.—SEPARATION OF OIL FROM WATER.

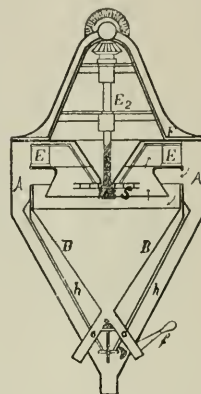


FIG. 14.—SEPARATOR.

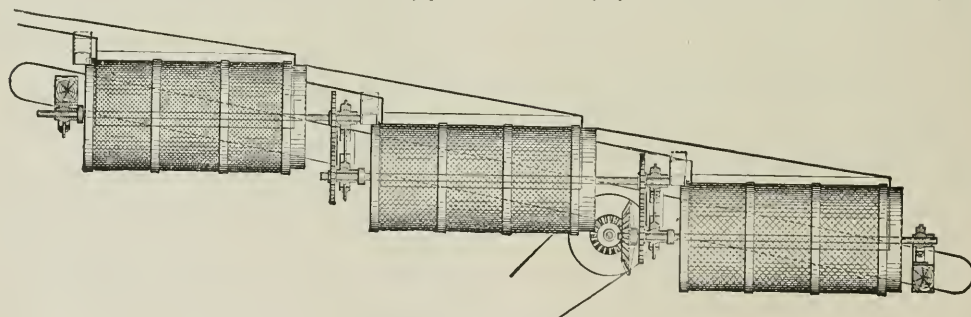


FIG. 13.—REVOLVING SCREENS.

the 1,400 mark. The exhibition was exceedingly well arranged, and the papers presented elicited very interesting discussions. On account of limitations of space we must reserve a fuller report for our next issue. Mr. L. L. Authes, of the Toronto Foundry Co., is the new president. Dr. Richard Moldenke remains the ever-active secretary of the association. The next meeting will be held in Cincinnati.

Nevertheless, some simple rules can be applied even in this case.

For some purposes, as, for example, ammonia stills, cast iron seems everlasting, and there can be no secret as to brands. One such apparatus, known to the author, is as perfect to-day as when it was erected 18 years ago, at any rate the cast iron part of it. There is no sign of wear in any of the

numerous cylinders; indeed, a remarkable thing was that the lower section of the line cylinders and the most important, as it has the manhole, leaked at the very start, a considerable blowhole making itself evident in the casting. Although the makers, with a full sense of justice, sent a new section to replace the faulty one, as the sill was up, operations were started, making good the bad place with rust cement (iron filings and salamoniac). Notwithstanding that the work carried on at a pressure of 8 to 10 lb. per square inch, the place has not leaked since.

In the case of ammonia stills the reactions are entirely basic, lime being used to drive away the fixed portion of the volatile alkali, but even acid chemicals have sometimes little action on cast iron. It is wonderful to see the length of time that a nitre pot made of this material will withstand the action of sulphuric and nitrous acids in a glowing furnace, the seething mass taking months and sometimes years to destroy the vessel. Yet when hydrochloric acid is in question cast iron succumbs like any weaker metal.

But while this is common knowledge the fact is not realized to its full extent. Percy ("Iron and Steel," page 145) describes the experiments* of Daniell, who obtained from a cube of cast iron, immersed in dilute hydrochloric acid, a spongy mass, easily cut with a knife, which was dark gray, somewhat resembling plumbago. He further gives Calvert's analysis of such a residue produced by the uninterrupted action of the acid during two years on cubes of the metal. Then he goes on to tell us of the similar action of seawater on cast-iron guns got out of an armed vessel that 50 years before had sunk near Carlscrona, which were found to be changed to the extent of one-third into a gray porous graphitic mass. Finally, Percy repeats the well-known instance of the guns, also of cast iron, raised from the *Florida*, one of the vessels belonging to the Spanish armada, which was sunk off the coast of Mull, in Scotland, and when brought up the graphitic mass into which they had been converted became so hot that it could not be touched.

These accounts, spread over such long periods, are little calculated to impress one with the violent and rapid manner in which the action may take place. The author found that the plug of a cast-iron cock, used to keep back ferrous liquor containing a very small percentage of free hydrochloric acid, was acted upon to the depth of one-eighth of an inch in a few months. This discovery was most opportune, for it caused the examination of a cast-iron vessel of considerable size into which the liquor in question was admitted, and a similar action was found to be going on. It was fortunate that this was perceived at so early a stage, for as little damage had been done, by a variation of the process that is in no way detrimental the action has been arrested, while the vessel is still good. Ammonia has to be used in the process, and a portion being put in at an earlier stage the acidity of the liquor and its injurious power are completely destroyed.

It is evident that this action of hydrochloric acid is one to be most carefully guarded against. Both the user and the maker of vessels that have to endure it are interested in the matter. Here then comes a distinction.

Cast iron is divided into two main groups, the white and the gray irons. The experiments of Prof. Daniell, already referred to, show that gray iron is more rapidly attacked than the white—three times as fast. Hence, if a cast-iron vessel is required to resist the action of hydrochloric acid it is reasonable to say that white iron should be selected. But other conditions may have to enter into one's calculation, and if the vessel has to resist internal pressure, as is often necessary, the tougher gray iron is preferable to the white and brittle. The iron-founder is, therefore, placed between the horns of a dilemma, and the natural way to get out of the difficulty is to

make a mixture of white and gray brand, the gray giving the tenacity and the white the acid-resisting power.

This, however, would not be so good as to cast around collapsible chills with gray iron, when the interior of the casting, assumed to be cylindrical, becoming white iron to a certain depth, would offer the required chemical resistance, while the outer coat of considerable thickness, remaining gray, would give the necessary tenacity. Vessels for chemical operations could certainly be produced on this plan, if it has not already been done.

In connection with the action of hydrochloric acid there are operations in which not only the unexpected, but the unsuspected may happen. Hydrochloric acid in its free state, and especially in its weak state, one knows that he must guard against, but chlorides seem so innocent that one is apt to overlook them. Now, ammonium chloride raised to 300° C. becomes dissociated, the hydrochloric acid being thus set free, what wonder, then, that the iron tar stills (Davis, Handbook of Chemical Engineering, 1901, vol. II, p. 260), which are heated to the melting point of lead (325° C.) are affected by the ammonium chloride that has not been separated from the raw tar?

Another point which it is important to note, and which is frequently overlooked, is that of not using wrought-iron chaplets to hold up the cores of pipes, etc., that are to be employed for chemical work. Failures are certain in such cases when the chemical has any action on iron, for the comparatively pure metal is more readily attacked than the cast iron. Even when cast-iron supports are used, failures may result, as the fusing together with the main casting may not be complete. The method of casting pipes vertically without the use of chaplets is, hence, to be recommended for chemical work.

The discussion on Mr. F. J. R. CARULLA's paper on "Cast Iron in the Construction of Chemical Plants" was begun by Prof. Turner, who remarked that alkaline hydroxides protected cast iron from rust, but it was not so well known that very weak acids—even dilute acetic acid—gradually dissolved iron leaving a graphitic residue of the original form. All varieties of cast iron were attacked by hydrochloric acid. Experiment showed that cast iron containing as much as 10 to 15 per cent of silicon was insidiously attacked. Nitre pots varied considerably in regard to the rate at which they were acted on. His experience was that with close-grained iron containing little phosphorus, like old Staffordshire iron, the action was reduced.

Mr. Harbord expressed his preference for white iron for tanks used for boiling sulphuric acid. Castings in white iron were not easily obtainable, but he knew of one case where they were made for dealing with boiling sulphuric acid.

Mr. Stead pointed out that strong sulphuric acid did not appreciably attack iron because ferrous sulphate is insoluble in concentrated sulphuric acid, but hydrochloric acid produced a soluble chloride with consequent continual exposure of fresh surfaces of metal to its action. The difference between white and gray iron in resisting the action of acids was due to the graphitic carbon in the latter forming couples with the iron, the action was inversely as the proportion of carbide in the metal. Steam sometimes, but not invariably, produced a gray film on cast iron. A specimen of high-silicon iron had been in his laboratory for several years without more than superficially tarnishing, and rubbing with a cloth restored its original brightness; but the high-silicon iron is unsuitable for castings by reason of its extreme brittleness.

Mr. Paul referred to a case in which 1 per cent of silicon in thin steel plate gave such trouble in pickling that tinning operations were impracticable.

Prof. Turner suggested that silicon iron might be used in cases where hammering and turning could be dispensed with.

Mr. Carulla then announced that he would publish his reply in the *Journal*, as he had received some communications which he wished to deal with. Aluminium might be advantageously employed instead of iron for operations involving the use of acetic acid. Although high-silicon iron was so brittle, yet it

*Calvert's analyses are given as follows. Cast iron: 95.413 Fe., 2.900 C., 0.790 N., 0.478 Si., 0.179 S., 0.132 P., loss 0.108. Residue: 79.960 Fe., 11.020 C., 2.590 N., 0.070 Si., 0.096 S., 0.059 P., loss 0.205.

might perhaps be used for linings and wrought iron could be employed for the exterior, but if this material would only last twice as long as ordinary iron it would not pay to use it. He thanked Mr. Stead for his remarks on the action of steam, which were new information to him.

The president proposed a vote of thanks, and remarked that the "cussedness" of matter often brought about unexpected results, but that was only equivalent to saying that our knowledge of the physical properties of materials was not so perfect as it was supposed to be. He instanced a case within his own experience in the ammonia-soda process where very dilute solutions caused pipes to constantly become filled with crystalline deposit, which, he facetiously declared, should not have occurred had Nature been properly organized.

Plate Rolling Mills.

A paper by Mr. ANDREW LAMBERTON discussed improvements in plate rolling mills, with special reference to the rolling of thin plates. The three principal conditions which platemakers must fulfil in England are: 1, quality, represented by the usual tensile and bending tests; 2, first-class surface finish throughout; 3, close adherence to gauge thickness. No such stringent conditions are made in the United States either with respect to first-class finish throughout or to close adherence to gauge thickness. While the author says that a margin of 15 per cent variation in thickness is sometimes accepted in the United States, adherence to gauge thickness in England must be generally within $2\frac{1}{2}$ per cent or under.

Were it not for the stringency of these conditions, the probability is that plate rolling-mills of the American three-high type would have been adopted in England before this time. It is unquestionable that for thin plates the three-high mill has some advantages; but, unfortunately, it has the great drawback of being unable to maintain high-surface finish on plates for more than two or three days, when the rolls require to be changed. This defect is inherent in the design of the mill where the roughing-down of the slab and the finishing of the plate are done in one set of rolls, causing rapid deterioration of their surfaces. The usual practice is to use a top roll and a bottom roll of equal diameter with a mid roll of two-thirds their diameter. At every pass of the plate, whether between top and mid, or bottom and mid, the mid roll does work, so that twice the work is put upon it that the top and bottom rolls are required to do, and, as it has only two-thirds of their surface, it wears much more rapidly, the surface becomes quickly injured. This necessitates the changing of the rolls every two or three days, which is a drawback of a very serious nature. To meet this the practice is to roll all plates requiring the highest finish during the first 24 hours' working of the mill and devote the subsequent one of two days' working to plates which do not require such fine surface or close adherence to gauge thickness.

English steelmakers have, with practical unanimity, adopted the two-high reversing mill; it is superior and much more regular with respect to surface finish; the drafting of the rolls is much simpler and admits of more ready adjustment; the live roller tables are much more reliable in that they are fixed and can be made as heavy and strong as desired.

Another very important advantage possessed by the two-high reversing mill is that, when roughing down slabs, during which the passes are short, the mill can be driven at slow speed, so as to minimize the shock when the slab enters the rolls, while during the long passes the speed can be accelerated to any desired extent compatible with safety. The author has taken notes of the speed at which reversing engines are regularly driven and finds 140 r.p.m. quite common. This is quite twice the speed of the three-high mills, so that the slowing down during the initial passes is amply compensated for before the finish. This method of working is obviously much easier on the mill plant than where the slab enters the rolls at full speed, as in the three-high system causing violent shock and increased liability to breakage.

While for these reasons the practically unanimous choice of English plate makers has been the two-high reversing mill, two new installations of three-high mills have recently been made, one in Scotland and one in England.

The chief part of the paper is devoted to a description of a new form of plate mill, having rolls 30 in. diameter by 6 ft. 6 in. long, designed by the author specially for rolling light plates, but equally suitable for ordinary ship and girder plates. This mill is now successfully at work at the Glasgow Iron & Steel Works, in Warshaw. The principal features of this new rolling mill of Mr. Lamberton are as follows:

Simplification in the Operation of Mill and Reduction in the Amount of Machinery Required.—This is accomplished by arranging the roughing and finishing rolls in tandem, instead of the usual practice of arranging them in the same extended line. The slab is first reduced in the roughing rolls, and finally in the finishing rolls. During the process of roughing down the top finishing roll is held up clear by its hydraulic balances, and the plate under treatment passes freely through the finishing rolls until reduced to the thickness ready for finishing, when the upper roughing roll is raised, and the upper finishing roll lowered and the subsequent finishing of the plate takes place through the finishing rolls.

Reduction in the Work Done by Finishing Rolls and Consequent Reduction in Wear.—In the ordinary type of mill, where the roughed-down slab has to be transferred sideways to the finishing rolls, the practice is to make this transference while the plate is still of considerable thickness that it may not cool too rapidly during the process, so that, generally speaking, as many passes are made in the finishing rolls as in the roughing-down rolls. The author considers this bad practice, inasmuch as it imposes a great deal more work and entails much more wear on the finishing rolls than is necessary. The operation of finishing should be done with the minimum number of passes, so as to reduce the wear on the costly finishing rolls to the lowest possible point and maintain their surfaces perfect as long as possible.

His new form of mill is specially designed to effect this, as the roughing-down process can be carried on during 80 per cent of the whole operations of rolling a plate, owing to the fact that it never requires to leave its direct line of travel, and the finishing process, representing some 20 per cent only of the whole work, is all that need be put on the finishing rolls. It is obvious that a very considerable saving must be effected in the finishing rolls, which have their work so substantially reduced and their surface will be maintained in good condition for a much longer time. Further, the expense in changing and dressing rolls will be greatly reduced, and stoppage of the mill rendered less frequent.

Acceleration in Delivery Speed of Finishing Rolls and Equalization of Power Used in Roughing and Finishing Rolls.—From careful observations and diagrams taken from engines driving two-high plate rolling mills it has been found that the process of roughing-down requires very considerably greater power than that for finally finishing the plate in the hard rolls. This means that the engine, which must be of sufficient power to give out the maximum demand made upon it, is over power when the finishing process is in operation, and the author utilizes this excess power in accelerating the speed of the finishing rolls over that of the roughing. This results in the double advantage of equalizing the load upon the engine during the whole of the operation and consequently increasing its efficiency, and also of providing a most useful increase in speed during the final passes when finishing the plate which, when rolling thin plates, is of very great importance.

Final Delivery of Plates, Straightened and Free from Wave.—In mills driven at high speed there is a tendency for the plate to become waved, particularly if it is of thin gauge, and the higher the speed the more pronounced is this tendency. To correct this, during the final pass in the finishing rolls, the roughing rolls are also put down in light contact with the plate,

and the mill then practically forms a four-roller mangle which very effectively flattens out the plate before going to the shears.

Further advantages are a *reduction in space* occupied by the whole plant (the saving in space amounting to about 40 per cent) and a *large output capacity*. The latter is obtained (1) by the simplification of the operation of the mill, in which the transference of the plate from roughing to finishing mill is abolished and the time taken for this operation saved; and (2) by the acceleration of the speed of the finishing rolls, which are driven 15 per cent faster than the speed of the engine. The result is that a plate of, for example, 5 ft. x 30 ft. x $\frac{3}{8}$ in., can be rolled in two minutes, and if this rate of feed could be kept up the output of such plates would be 400 tons per day of 10 hours. In rolling to thin gauge the slab is thinner and the time taken for a plate of, for example, 5 ft. x 30 ft. x $\frac{3}{16}$ in., is two and a half minutes, or at the rate of 130 tons per day of 10 hours.

Special attention has also been paid to *steam consumption*. The engine driving the mill described is of the vertical and horizontal type, compound condensing, and has a high-pressure cylinder 42 in. diameter and a low-pressure cylinder 67 in. diameter by 4-ft. stroke. The steam pressure is 160 lb. per square inch; the exhaust is connected to a central condensing plant giving a vacuum of about 24 in., and the engine under these conditions develops the exact amount of power required.

To ensure quick reversing the handling valves of both high-pressure and low-pressure cylinders are connected and worked in unison from the same starting handle as is now usual in modern compound engines. The closing of both these valves simultaneously acts as a most efficient brake, stopping the engine quickly and preventing racing at the finish of the passes. The resulting increase in pressure in the receiver is then available for accelerating the speed of starting for the return pass, and so the efficiency of the whole operation is substantially improved.

Finally the author refers to the question whether the rolls should be worked wet or dry. The finishing rolls are generally worked wet, but this is not so with the roughing rolls. It seems only reasonable to believe that, if all rolls could be worked wet, it would greatly extend their life and would prevent necks overheating and cutting into their bushes. "The solution is to be found in the increased speed of driving which enables plates to be rolled with such rapidity that the cooling effect produced by working the rolls wet is discounted by the heat generated by the work expended on the plate in reduced time. From careful experiments made on a large number of plates rolled from the same slabs it has been ascertained that the surface quality of plates rolled when both roughing and finishing rolls are worked wet is very distinctly superior to those produced when only the finishing rolls are worked wet. This clearly points to the advisability of all plate rolls being worked wet."

The discussion of Mr. Andrew Lamberton's paper was then opened by Mr. James Riley, who said it was a real pleasure to him to have read and listened to this paper. Thirty years ago the mill at Hallside works turned out 80 tons per week on one shift and the workmen said the rolls could not do more without getting hot—"they would burst;" but the modern output was 2000 tons. The first three-high mill in this country he put down 15 years ago. It turned out three times the weight of plates that the old mill did; but the roll gave trouble, particularly the tables. He agreed almost entirely with the author's conclusions except, perhaps, that the complications in the motor required consideration.

Mr. Harrison quite agreed with the majority of Mr. Lamberton's proposals, but doubted whether the "mangling" action resulting from the top roughing roll being lightly let down at the finish would be quite satisfactory, because if let down too lightly there would be practically no effect, and if too hard the plate would be stretched too much. Did the author want to heat

plates by the work done on them in the mill? If so, it was an expensive way of heating.

Mr. Gledhill said that if he reconstructed his armor plate mill he should follow the author's excellent arrangement. But with regard to rapidity in rolling plates exceeding a certain thickness, when the surface is worked out at a higher rate than the interior, the centers become unsound and the ends of the plate are distinctly concave. Immunity from breakdown was very important. In the structure of his armor plate mill castings were not accepted; the rolls, 4 ft. in diameter, were forged from ingots of nickel steel of 80 tons each, and the housings and light engine cylinders were also made from forged steel ingots. There had been no breakdown in seven years' continuous working.

Mr. Cunningham felt quite sure tandem rolling would come to the front. The best distance between the rolls would be determined by experience. He estimated that at present 63 per cent of the work was done in the soft rolls and 37 per cent in the hard rolls. Experiments on wet rolling with plates $\frac{5}{16}$ in. thick and less showed a saving of 1.5 per cent in pickling solution for wet-rolled plates, owing to a lower proportion of surface oxide.

Mr. Crowe thought that two sets of three-high rolls driven by independent engines would give a larger output than a mill on the author's plan; but that entailed increased expense. Mr. Lamberton's mill would probably give the greatest output to be obtained with one engine. Against the saving in time effected by the abolition of skidding, the time occupied in screwing down should be considered. Then, too, the condition in which the plates were received from the cogging mills counted considerably. He considered that the housings of the two mills might be advantageously placed farther apart. He congratulated the author on the production of a reversing engine of the type described, and thought these rolls especially adapted for electric motive power. No doubt the slight stretching consequent on the the soft rolls running somewhat more slowly than the hard rolls during the "mangling" action would effectively straighten the plates.

Mr. Duff said the output of Mr. Riley's three-high mill in 1890 was often more than 400 tons per week. He quite agreed that fast, wet running produced superior surface finish. The great defect of the three-high mill was the weakness of its live-roller tables, and if this had been remedied he had no doubt that the output and general results would have at least equalled those obtained by the author's mill.

Mr. Lamberton replied that Mr. Riley need have no fear of complications arising from the engine. It had all the advantages of double-compound engines with less complication. The high- and low-pressure valves were connected by rods to a single lever, and when shut down they closed together, and formed a most efficient brake, which quickly brought the engine to rest. Mr. Riley's estimate that the mill could roll plates 80 ft. long might be exceeded; he hoped to produce plates 100 ft. long. Putting the rough holls lightly down at the finish straightened the plates not so much by stretching as by preventing wobbling. Mr. Harrison had enquired as to the plate being heated in working. He did not undertake to heat plates by putting work into them at high speeds, but what he said was that the rapidity of rolling diminished the loss of heat by cooling in the mill. Mr. Gledhill's remarks referred mainly to armor plates, the conditions appertaining to which were quite different from those of rolling thin plates. He did not claim priority in the use of a reversing-compound engine, but only for the two-cylinder engine as distinguished from the four-cylinder engine. Mr. Crowe's proposed combination of two three-high mills would obviously increase the outlay with the production, and he saw no advantage in increasing the distance between the housings, which would complicate the transmission gearing. Electric driving was simply a question of cost, and meant two 3000-hp motors instead of one engine. He perfectly remembered the three-high mill mentioned by Mr. Duff,

but not favorably. It was a somewhat shaky structure, frequently stopped by breaking down, and it was difficult to reconcile Mr. Duff's statement of its performance with the fact that it was not now in existence. In conclusion, he claimed that the correct method of rolling plates was to equalize power between the soft and hard rolls.

The president moved a vote of thanks to Mr. Lamberton, and congratulated him on his valuable work. Those who had taken part in the discussion were also to be commended for their observance of the time limit and their close adherence to the subject-matter of the paper.

A New Fatigue Test for Iron and Steel.

A paper by Dr. T. E. STANTON, of the National Physical Laboratory (London), describes a new fatigue test for iron and steel based on observations of Kirkaldy, who traced the failure of steel rails to the development of cracks in the upper worn surface, brought about by repeated bending. Dr. Stanton, therefore, devised a laboratory test combining rolling abrasion and alternate bending. The principle is shown in Fig. 1.

It is a hollow ring of rectangular section cut from the steel rail to be tested, and placed between three hardened steel rollers symmetrically placed as shown. If the upper roller is loaded with a weight W , the ring will be in equilibrium under three equal forces W at the lines of contact and by rotating the upper roller motion will be communicated to the lower one by the rolling friction of the ring.

In this way the outer surface of the ring will be subject to rolling abrasion, and every radial section of the ring will be subject to alternate bending stresses which will go through a complete cycle three times in one revolution, and the magnitude of which can be calculated from the dimensions and the load.

A machine based on this principle works satisfactorily with the exception that the load on the upper roller could not be made considerable, owing to the resistance of the bearings of the lower roller which soon became greater than the frictional resistance at the line of contact with the specimen. The result was that when this limiting load was reached, the specimen ceased to rotate and a flat was at once worn on its surface by the upper roller, rendering it useless for further testing.

A new machine was therefore designed and constructed, and is shown in Fig. 2. In this the axes of the lower rollers are supported on the rims of friction wheels, an arrangement which

the machine, and motion is communicated to it from a shaft parallel to its axis through an Oldham coupling, which allows the roller to sink without constraint as the specimen wears away. The load is applied by a weighted lever whose knife-edge rests on a saddle supported from the bearings of the upper roller by the side rods shown in Fig. 2.

The behavior of a specimen under test consists of a wearing down and spreading over the edges of the outer surface to an extent depending upon the hardness of the material. After some thousands of rotations the surface begins to slightly disintegrate and falls off in thin flakes. As the test proceeds, after a time, depending, of course, upon the load, small cracks running parallel to the axis begin to appear on the inside or outside surfaces, or both. These develop until the specimen is no longer able to sustain the load and fracture occurs. On examining the surface of a specimen after fracture it will be generally found that there are innumerable small cracks running across the surface parallel to the axis which are only visible in the microscope.

The author illustrates the application of this method by giving the results of a number of tests made on specimens cut from sample rails of an English railway company. The results indicate clearly the marked superiority of nickel-steel rails, both in regular resistance to rolling abrasion and resistance to alternating bending. The number of reversals of stress up to fracture is very materially greater with nickel-steel than with other steels.

The calculated ranges of stress from tension to compression at the outer radius of the test ring were from 35 to 40 tons per square inch. The calculated stresses at the inner radius were about 15 per cent greater, but it is noteworthy that the cracks which ultimately caused the failure of the ring appeared to originate on the outer surface of the ring in the case of the hard steels and on the inner surface in the case of the softer steels. This is probably due to the greater spreading of the material sideways in the softer rings, due to the rolling abrasion.

Another interesting result is that although, broadly, a high value of the hardness number corresponds to long endurance to alternating stresses and abrasion, yet in several cases an increase in the hardness number is accompanied by a diminution of endurance. Another feature of the tests is the greater endurance of the two samples of least tensile resistance and greatest ductility. This is probably also due to the spreading and hardening of the material at the outer surface of the soft steels. A similar effect to this in practice has been observed in which it was found that the loss of weight for the first 30,000 trains was 28 per cent greater for the soft than for the hard rails, but that the wear due to the next 65,000 trains was 9 per cent greater for the hard than for the soft rails.

Dr. T. E. STANTON having read his paper on "A New Fatigue Test for Iron and Steel," Mr. Gledhill led the discussion. The paper was decidedly instructive and appealed to him particularly because it demonstrated the superiority of nickel steel. But the test rings were so cut that the strains were in a longitudinal direction, and it would be more useful to take the sample rings transversely. The apparatus was ingenious and practical.

Mr. Hadfield thought the method of test was original and congratulated the author. Low-carbon nickel steel would not wear well, and he enquired if Dr. Stanton had records of nickel steel rails in service. He considered this a most important matter.

Mr. A. Windsor Richards did not think the test comparable with service conditions, nor were the results comparable in themselves, for the hard rings gave way exteriorly and the softer samples interiorly. One rail which had stood 35 years' wear had given bad results in this test, and would probably have been rejected if it had been made to-day. Then, too, rails with high phosphorus and sulphur showing but slight wear after 25 or 30 years broke down under the reversal test. The selection of the portion for test was unfortunate; it was the weakest:



FIG. 1.—PRINCIPLE OF TESTING MACHINE.

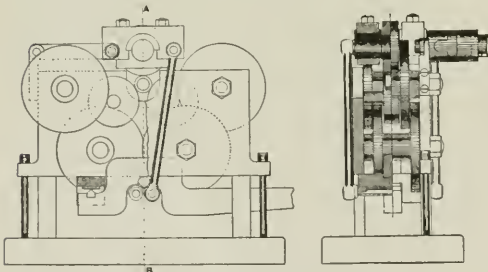


FIG. 2.—FATIGUE-TESTING MACHINE.

proved quite satisfactory, the specimen rotating uniformly up to the highest loads used until fracture occurred.

The rollers and their axes are made of tool steel hardened and ground to the same diameter. The upper roller revolves in a double brass bearing, which is hinged to the side plates of

part; a thin layer should be taken just under the running surface.

Mr. E. H. Saniter pointed out that the ring as selected would have two different directions of fiber. Fracture did not occur in these tests in the same direction as under service conditions; he considered the test unsuitable and that results given on p. 10 of the paper indicated that the test was not reliable.

Mr. W. Webster hoped the experiments would be extended, but test pieces should be taken with their axes parallel to the length of the rail. Certain thin sections from the head of a rail would bend longitudinally into a semicircle of $1\frac{1}{2}$ in. radius, but with transverse bending they broke at 20 deg.

Dr. Stanton, in reply, said he only wished to illustrate the method of testing and not any particular results. He was glad attention had been called to the selection of specimens for test. He had adopted the plan described as that by which the action of wheels on the rails would be simulated as nearly as possible.

Mechanical Treatment of Steel.

A paper by Mr. JAMES E. YORK (New York) discusses the physical qualities of steel in relation to its mechanical treatment and emphasizes that, especially for rail making, the mechanical treatment of the steel is comparatively of much greater importance than its chemical composition, the latter being now well under control.

The chemical composition of steel ingots may be all that can be desired, but if they are not properly heated the quality of the steel is seriously affected. It seems rational at first sight to consider as the most successful heater a man who can guess the hottest temperature, at which the steel will roll without cracking, as naturally the hotter the metal the softer it is, and hence the reduction is easier and more rapid. However, this method has two serious defects; first, that overheating destroys the best structure of the steel, and, in addition, the finishing temperature is so high that no proper fining of the grain is possible.

Mr. York strongly urges to stick to these two principles: 1. That the finishing temperature should be as low as is possible to get best results, and that the initial must not be above another limit, about 950° C. 2. That if under these conditions the ingot cannot be rolled to 4-rail lengths in one operation, the initial size should be reduced.

Mr. York discusses the lack of penetrative action in rolling and, as a consequence, the impossibility of closing a pipe in the rolling mill, the pipe being merely stretched proportionally with the billet. Therefore, it is absolutely essential that the ingot should be comparatively free from pipes and blowholes before the operation of rolling commences in the blooming-mill, otherwise there cannot be produced a billet of proper structure from the top of the ingot, and consequently the rail with the necessary physical qualities cannot be produced unless the ingot is solidified before it is bloomed, or the necessary top portion sheared off after.

The necessity for some cheap, quick and efficient method for solidifying ingots has induced Mr. York to apply his method of transverse rolling to this problem. Fig. 3 shows an end elevation of the mill with six ingots in place for treatment.

The ingots are arranged alternately reversed so as to save room, and the number of ingots may be increased or diminished as is found desirable or the dimensions of the mill allow. The ingots lie on a comparatively level horizontal table, and are first operated on by the plain roll No. 2, which closes any surface blowholes.

The ribbed roll No. 1 is so constructed that the distance between the ribs corresponds to the distance between the centers of ingots and the corresponding rib on the base; the ribs are preferably made removable so that they can be provided of the right length and contour to suit any particular series of ingots, but in all cases the rib must be longer than the pipe to be eliminated. The operation of rolling involves the use of comparatively little power, since the metal is merely shifted inwards along the line of the pipe.

It will usually be sufficient, owing to the taper of the ingot, to have ribs of the same depth throughout, and in consequence the rib will make contact first at the bottom of the pipe, and will gradually squeeze out any segregated material. However, if desired, the ridge may be tapered, or the plain roll may have a collar at any particular point for the purpose.

With this method the ingot will be left with two grooves of semi-circular section which, however, will not interfere with the subsequent rolling. To avoid this, if desired, the ingot may be cast with ridges, which when forced in will leave the surface comparatively plain.

In then discussing the rail-finishing mill, the author points out that the work done by the rolls working with their faces parallel in the manufacture of blooms, plates and flats is satisfactory. It is only when rails and other flange sections have to be produced that the more elaborate rolls required do not give the same satisfactory results.

It is clear that the metal in the web and head is the only part of the billet which receives any material reduction, and as the

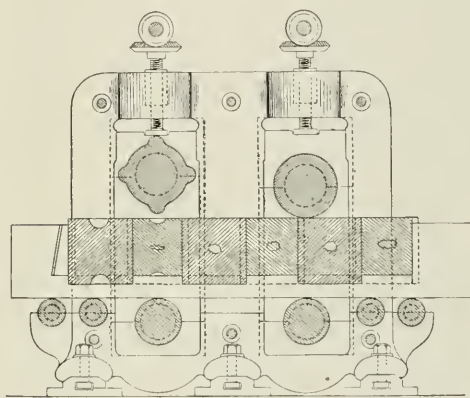


FIG. 3.—ROLLING MILL.

flanges and head are gradually formed, less and less true rolling action is performed upon them. The action which can take place in these parts, where the roll surface is at right angles to the rail, can only be largely of the nature of wedging or drawing. The result of this must be a condition of unequal stress in the flanges.

Another serious defect in the use of these rolls for flange sections is the great difference of surface speed at different parts of the section, the diameter of the roll forming the wedge being frequently 5 inches larger than a portion in contact with the extremity of the flange, and sometimes more. As a consequence the web is delivered from the roll much faster than the flange, where the metal must either slip or stretch to compensate for this. This is the principal reason why, when the flange breaks, the fracture is almost always crescent-shaped.

By a method which he describes, Mr. York has established the fact that the remarkably good quality exhibited in certain rails made forty years ago was obtained by rolling at a low initial temperature. Taking a 14-inch ingot he found that it required thirty-two passes to obtain a 65-lb. rail. "It is not to be supposed for a moment that the most skilful steel manufacturers in the world at that time were working there at a lower capacity for amusement, and if similar good qualities are required to-day it is necessary to work under relative heating conditions."

At the present time a 22-inch square ingot weighing 2 tons can be rolled into four-rail lengths in fifteen to twenty passes, and it is clear that a considerably higher initial temperature must be employed, with the result that there is less effective

work on the material, and that the resulting quality is inferior.

Steel rolling, with the conditions of greater hardness and lower temperature, requires a harder and stronger roll than was the case with iron. However, the only class of roll which keeps its shape under the condition of work now required is the hard chilled roll, which cannot be adapted for deeply-grooved rolls, as now used in rolling rails at the finishing passes.

Mr. York finally refers to his universal mill, which can give the finishing passes at the lowest possible temperature and with the hardest surface to the rolls. Owing to the special construction of this mill, beams of small depth with a 12-inch flange can be delivered perfectly straight from the roll. Also, owing to the presence of the side roll, rails can be produced without the internal strains mentioned above, and, in consequence of the possibility of doing more work there with a better wearing quality metal in the head.

The high speed given to rolls in modern rail-mills has often been considered to be one of the chief causes of inferior rails. This is in a large degree a mistaken idea. If the metal being rolled is comparatively solid and has not been overheated and the rolling action is on proper lines, there will be no damage to quality other than incidental to the shape of pass; the speed of delivery of a modern rail-mill is about 650 feet per minute.

The York universal mill is now rolling beams at a speed of about 1600 feet per minute without deteriorating the physical qualities of the finished product. This is made possible by side-rolling action, which dispenses with the different speed delivery referred to in the ordinary mill, also the wedging and drawing action now inherent to the ordinary process when rolling rails and other flange sections.

A New Electric Steel Furnace

A paper by Prof. B. IGWESKI (Kieff, Russia) describes "a new type of electric furnace for the smelting of iron" (already briefly described in our Vol. V, p. 141). The chief advantages are stated to be the use of high voltage, absence of carbon electrodes, a high temperature of the slag, and a "minimum amount of surface contact with air or with the walls of the furnace."

The furnace is of the resistance type and the special feature is that the resistor is a conductor of the "second class" (electrolytic conductor), like magnesia, lime, silicates or their colloids, such as Al_2O_3 , 2SiO_2 , which, on being greatly heated, become conductors.

Fig. 4 is a cross-section of the furnace; *a a* are fire bricks, the inner surfaces of which form the resistor proper; *b b* are thin iron-sheets inserted between the bricks and leading the three-phase currents from the collector brushes *e* outside to the inside of the furnace. These brushes *e* are stationary, while the furnace rotates in the direction of the arrow, at a speed of about 20 revolutions per minute; *c* is the molten charge.

The author states that he has had several years' experience with this furnace, but only in the laboratory. The author prefers the use of three-phase currents, but usually employs a continuous current of 250 volts and 50 to 60 amperes, i. e., 12-15 kilowatts. When cold the furnace is a non-conductor.

The process of smelting is conducted in the following sequence of operations: The flame of a gas or Bunsen burner is made to impinge through the working opening, and when the furnace has been slightly warmed a little damp potassium hydrate is charged and the furnace is rotated. It will now be found that the furnace acts as a conductor, and the electric current begins to warm it. After a short time sodium hydrate is added, and when the interior of the furnace is red hot, sodium carbonate is charged. The corrosive alkalis which evaporate within the furnace do not cause as much harm as might be expected. Rapid heating is, however, a danger to the bricks, which begin to crack.

The best plan is to warm the furnace with gas during the night preceding the experiment. When the temperature of the furnace reaches a light red heat cast iron may be put in, and then scrap, or the order can be reversed. In the first case the

author is in the habit of adding the new material gradually as the charge melts. In the latter case, when the iron becomes sufficiently hot, the smelting takes place at once on the addition of cast iron.

If a quantity of cold metal be suddenly introduced at one time, it is easy to reduce the temperature to such an extent that short circuiting occurs. The same thing occurs if the furnace becomes cool with the metal inside; small furnaces cool down in an exceedingly short time. In a large furnace where there is a considerable margin of heat, such an accident is hardly likely to occur. Indeed, in order to bring them into working condition, it would suffice to charge some hot slag from some other furnace and to avoid having recourse to soda, which could not be other than injurious to the bricks.

"The outer bricks of the author's furnace are of fireclay, and the inner of fireclay or dinas. The fireclay bricks are fairly good conductors, but the dinas bricks are exceedingly poor conductors. The author has, however, used both for years with successful results. With fireclay bricks care should be taken that less slag should be used. With dinas bricks it is his custom purposely to add fluorspar, cryolite, magnesia and similar substances in order to increase conductivity.

"Magnesite bricks appear to be ill-adapted to the purpose, because they conduct too easily, while the current of 250 volts

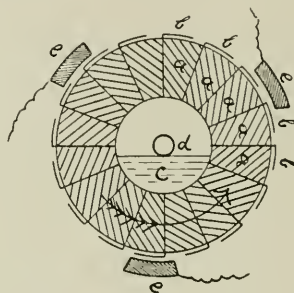


FIG. 4.—ELECTRIC STEEL FURNACE.

would, with the existing dimensions of the furnace, be too great for these bricks. Experiments with dolomite and other bricks have not yet been carried out by the author."

As a rule the author smelts a small quantity of cast iron and afterwards adds scrap. "The softest steel produced possesses an ultimate strength of 56.8 kilograms per square millimeter, with an elongation of 20 per cent."

On smelting iron turnings with charcoal (1 per cent), steel was produced with an ultimate strength of 85.6 kilograms per square millimeter, and an elongation of 3 per cent. Experiments for the production of steel from cast iron by the ore process were also successful, and the fireclay bricks suffered less than might have been anticipated.

Color Photography in Metallography.

A paper by Mr. E. F. LAW (London) deals with the "application of color photography to metallography." In the examination of alloys under the microscope a difficulty is frequently met with in selecting an etching agent capable of distinguishing the different constituents, and this is especially the case when it is required to show the constituents in a photograph.

In order to overcome the difficulty, and increase the actinic contrast between the constituents of an alloy, Professor Martens suggested heating the polished specimen until a film of oxide formed on the surface. Owing to the different rates at which the constituents oxidize, they assume different colors, and can be readily distinguished and photographed.

The same results, but sometimes showing more brilliant colors, may be obtained by simply allowing the polished surface

to tarnish by exposure to the atmosphere, and modifications of the process consist in heating the specimen in air containing iodine, bromine or sulphuretted hydrogen.

In such cases the present author has found the Lumière autochrome plates to be very useful for producing colored microphotographs. The disadvantage of the process (but probably only a temporary one) lies in the difficulty of obtaining prints on paper. On the other hand, the time spent in the dark-room is about three minutes, most of the operations being carried out in full daylight, and a photograph can be taken, developed, dried and bound as a lantern slide in less than one hour.

(To be concluded.)

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

Faraday Society Meetings.

At the meeting of the Faraday Society, held on February 25, a paper by Dr. Veley on hydrolysis and a paper by Dr. Knox on a study of the sulphur anion and of complex sulphur anions were presented which were chiefly of theoretical interest, but elicited a very extended discussion.

At the meeting on April 28, papers were read by Professor A. K. HUNTINGTON and Dr. C. H. DESCH on "The Planimetric Analysis of Alloys and the Structure of Phosphor-Copper," and by F. E. WESTERN and H. R. ELLIS on the "Interaction of Aluminium Powder and Carbon." (See page 250 of our June issue.)

In the discussion on the first of these Professor W. W. Haldane Gee communicated a suggestion that the method might be used to compare the relative losses of the constituents of an alloy after prolonged etching with different reagents, and so help to throw light on the method of corrosion. It would be of especial interest to apply planimetric analysis to alloys which had been electrolytically corroded as anodes in various saline solutions.

Replying to a question, Dr. C. H. Desch said that general applicability was not claimed for the method, for where the alloy was homogeneous—as in many low percentage bronzes—it was useless. Also a state of physical equilibrium was essential; and slow solid diffusion often took place even after careful annealing. The chief point that he wished to accentuate was the effect of segregation, for this had not been previously pointed out; and he believed it occurred more generally in alloys than was usually supposed.

Professor A. K. Huntington remarked that when proper curves were obtained the method would probably be satisfactorily extended to the examination of phosphor-tin alloys. The subject would well repay study, as by its means insight was gained into the constitution of alloys which can never be supplied by chemical analysis.

Discussing Messrs. Western & Ellis's paper, Dr. F. Mollwo Perkin said he did not altogether acquiesce in the view that the reaction was due to reduction of CO and CO₂ subsequently to the oxidation of the carbon. He had no evidence that CO could be reduced at 1100° C. Possibly the heat evolved by the action of the nitrogen on the aluminium might contribute. It would be of interest to heat aluminium powder in streams of CO and CO₂ and observe the temperature at which reduction occurred. The initial reaction was more likely to proceed from the superficial oxidation of the aluminium.

Mr. Charles Weiss mentioned that carbides were sometimes found in the complex matter at the bottom of the aluminium furnaces; and generally these carbides were entirely enclosed in an envelope of aluminium oxide.

Mr. H. R. Ellis gave further particulars concerning the production of nitride, and stated that he considered that the formation of nitride was more probably due to the action of nitrogen on the carbide at a high temperature than to the nitrogen combining directly with the metal, for it has been abundantly dem-

onstrated that the carbide is readily attacked by nitrogen at high temperatures. Crude carbide strongly heated in a stream of nitrogen readily absorbs this gas, which is evolved as ammonia on treatment with water; but for the successful absorption certain impurities are necessary. The crude carbide can be prepared from clay and carbon in an electric furnace, and might possibly be used to absorb atmospheric nitrogen as successfully as calcium carbide is used in the cyanide process.

Professor A. K. Huntington was disposed to agree with Dr. Perkin as to the cause of the reaction, but possibly the reaction was of a triple nature and was brought about by the presence of CO or of CO₂ between the two solids which would not interact alone. Reactions between solids were often induced with difficulty, and in this case the gas, unlike the solid carbon, might permeate the film of oxide enveloping the aluminium, thus reaching the actual metal and starting the reaction. He greatly appreciated the care with which the experiments had been conducted by the authors, and the consequent value of their work.

Dr. Richard Seligman communicated his concurrence with the conclusion that the carbon and aluminium unite directly, and that the intermediate formation of carbon monoxide is not necessary. He had often found the carbide in parts of the furnaces to which air could scarcely find access.

Mr. F. E. Western, in reply, said that he felt certain that the initial action was the oxidation of the carbon. This was evident from the appearance of the reaction, which began at a dull red heat beneath the surface, and bright incandescence at the actual surface followed—but not immediately. Unquestionably CO was produced, because its blue flame was apparent in cases in which the crucible had cracked.

MAY MEETING.

At the ordinary meeting on May 12 three papers were read. The first was by L. O'DOWD and F. MOLLWO PERKIN on "The Determination of Boiling Points of Very Small Quantities of Liquids."

In the discussion Dr. Senter asked if it were quite certain that the liquid in the inner tube has the same temperature as the surrounding liquid. The liquid in the inner tube was not stirred, and its temperature might not be quite uniform; moreover, this would be affected by the velocity of cooling through the walls of the thin tube.

Dr. Perkin replied that the test tube was of very thin glass. He estimated that the difference from the true value would not be greater than one-tenth of 1°. Stirring as described effected equalization of temperature.

Dr. Perkin then read his paper on "The Industrial Uses of Ozone," particularly for the purification of water.

The chairman, M. Leon Gaster, opened the discussion. He said that the subject was one of great interest, and described a large ozonizing plant at Philadelphia which was very satisfactorily used to purify the Schuylkill river water, reducing the number of bacteria from two-and-a-half millions to only twenty-five per cubic centimeter. Boiling was not so effective as was commonly supposed; water required to be boiled three times to remove bacteria with any approach to completeness. Filters were dangerous, because proper cleansing was not always attended to if it were practicable. But ozone destroys bacteria altogether. He wished to ask the author how the apparatus was regulated for production of ozone without oxides of nitrogen. It was a great triumph for the electrochemist to have produced such an apparatus—especially the portable form.

Dr. Veley remarked that some years ago when working on pure nitric acid he found that the best method of removing traces of nitrous acid was to let the nitric acid trickle through an atmosphere containing ozone. As to the residual bacteria, it was fortunate that pathogenic organisms were easily destroyed. Some bacteria would stand anything, even rum of 80 per cent, and as a rule such were not harmful. A reliable account of sterilization by ozone was most useful, because some forms of apparatus merely passed current through the water,

and the public was led to think that this effected ozone sterilization.

Dr. Lowry was more impressed with the portable form than with the larger plants. For town supplies he advocated the lime softening process, in which the precipitated calcium carbonate removed bacteria.

Dr. H. Borns considered that the self-purification of river water by oxidation, when the flow was rapid, rendered but little purification necessary. Siemens and Halske's bacterial figures had been assailed, but the results were certainly favorable.

Dr. G. Senter asked if there were difficulty in removing the last traces of ozone from the water. With regard to the proportion of ozone obtainable, Fischer had got 30 per cent.

Dr. Perkin then replied that in the Siemens' apparatus oxides of nitrogen were not produced. The quantity of ozone remaining in the water after treatment was very small, and was entirely removed by subsequent oxidation.

At the conclusion of the meeting Dr. Perkin exhibited a form of the apparatus at work.

Dr. V. H. VELEV's paper on "An Apparatus for the Determination of the Dielectric Constants of Non-conducting Liquids" was not discussed.

LORD KELVIN.

Sir Joseph Swan occupied the chair at the meeting on May 26, when Sir OLIVER LODGE delivered his presidential address, his subject being "Some Aspects of the Work of Lord Kelvin."

Sir Oliver said that when a man of the first magnitude worked from less than twenty to over eighty years of age the output was so great that no criticism could render complete justice. He would review only the chemico-physical part of Lord Kelvin's thoughts to the kinetic theory of solidity—that matter in its ultimate state might be the product of ether in motion. Some years before his death he seemed to be abandoning his position; and when, at a meeting of the British Association, Sir Oliver challenged him as to the constitution of the atom, he fully justified his views though not proving their correctness. It may seem that he was satisfied with the postulate of action at a distance across empty space instead of through a connecting medium, but that may have been but a stepping stone to a still greater theory.

What great generalization will be associated with Lord Kelvin's name? It is not easy to answer; but what emanated from him in 1851, when immersed in the doctrine of the conservation of energy, would perhaps constitute his greatest memoirs. His keenness and perception then were astounding. Grasping all the known theories, he seized on facts emanating from Carnot and Joule, and elicited therefrom a series of striking and beautiful discoveries. The answer of posterity will probably be the development of the doctrine of conservation of energy and its application to thermodynamics.

Joule's work might have been altogether rejected but for Lord Kelvin's recognition of it. Heat can be converted into work, and is not like water in this respect, nor like electricity. Carnot, with others, thought differently; but Joule proved it.

Of all the memoirs dealing with electricity, "Transient Current," published in 1853, is perhaps the most striking, giving the whole theory of electric oscillations. The fundamental equation was an inspiration in 1853, although it is written glibly enough now. The idea of kinetic energy in a current—the starting point of self-induction—really dates from 1848. It seemed to Sir Oliver an amazing kind of insight which led Lord Kelvin at that period to attribute something akin to specific heat to electricity. In his investigations of thermoelectricity he met with the good fortune that often attends those who do not hesitate to incur risk. There was a possibility that his discoveries might not have turned out to be true; but they have proved so.

In connection with Lord Kelvin's work on absolute measurement, Sir Oliver remarked that the invention of suitable units for electrical and mechanical measurements was not a simple

matter. Absolute measurements had nothing to do with the C.G.S. system, but might be based on wave-length or atomic mass. The establishment of the absolute zero of temperature was one of Lord Kelvin's achievements. It might be defined as the temperature at which a working substance had exhausted all its heat in doing work, and it was remarkable how various formulæ dealing with great or small expressions of quantities gave the same result.

On the electrical theory of matter Lord Kelvin's mind was somewhat conservative, but we owe to him some pioneer work, instanced by a remarkable paper in the *Philosophical Magazine*, 1891, "Epinus atomized."

Referring to Lord Kelvin's researches in celestial dynamics, Sir Oliver said the density of the whole visible cosmos was that of a vacuum as much rarer than our best obtainable vacuum as that is rarer than lead. If the whole of the matter therein were reduced to globules 2 cm in diameter uniformly diffused, light would be but slightly interrupted by it.

Atoms coalescing would take 17 millions of years to reach the density of water, and only two hours longer to attain infinite density at the universal gravitic center.

Sir Oliver did not see any reason to suppose either a beginning or an ending of matter or of space. Lord Kelvin appeared to think differently.

The chairman, in moving a vote of thanks, which was accorded by acclamation, congratulated the Faraday Society on its choice of a president.

Market Prices.

The run of market prices in May was as follows:

Tin:—During May tin has shown a constant downward tendency, varied only by a rise from 132-10 to 137 from the 13th to the 19th. The total drop during the month is from £142 5 0 to £130 17 0.

Copper has been flattish, with a rise to £59 on the 19th. Present prices of electros, £59 10 0 to £60 0 0. Total variation on standard for 1st to 26th nil.

English lead has declined steadily, with slight revival on 19th. Total variation within a pound. Present price, £12 17 6.

Hematite experienced a sharp drop on the 19th, but had total variations within a shilling. Present price, £3 0 6.

Cleveland warrants varied rather suddenly, starting at 31s 6d they rose steadily till the 8th, when the rise became rapid, culminating in 55s 6d on the 14th. After this came a sharp fall to 50s. Present price, £29 7½.

Scotch pig has fallen off slightly. Present quotations range from 63s Langloan to 56s 6d Eglington.

Chemicals.

	£	s	d
Ammonia sulphate, f.o.b. Liverpool, per ton.....	12	5	0
Copper sulphate, per ton.....	21	15	0
Caustic soda, 77 per cent, per ton.....	11	2	6
Bleaching powder, 55 per cent, per ton.....	4	5	0
Antimony, Star Regulus, per ton.....	35s	to	36 0 0
Shellac, standard T. N., orange spots, per cwt.....	5	8	0
Carbolic acid, liquid, 97.99 per cent, per gal.....		1	0
Creosote, ordinary good liquid, per gal.....		2	
Naphtha solvent, per gal.....		2	6
Rubber, Para fine, per lb.....		3	9
Gutta percha, fine, per lb.....		5s	6d to 6 6

American Chemical Society.—As announced before, the thirty-eighth general meeting of the Society will be held in New Haven, Conn., June 30, July 1 and 2. The Society will, as usual, meet in sections on account of the large number of papers to be presented. The sessions will be held in the Sheffield Scientific School of Yale University. Papers must be sent to the chairman of the section or to Dr. Charles L. Parsons, Secretary, New Hampshire College, Durham, N. H. A division of the Industrial Chemists and Chemical Engineers will be organized at this meeting, and a large attendance is expected.

SYNOPSIS OF PERIODICAL LITERATURE.

Industrial Electrochemistry.

Bleach Liquor for Paper Mills.—An article by A. Ahlén in the *Papier Zeitung*, Vol. 33, page 834, and abstracted in *London, Elec. Eng'ing* of May 7, deals with European practice of making bleach liquor for paper mills. As a rule, rock salt is employed to prepare the liquors which upon electrolysis produce the bleaching solution. But as the sodium chloride contains considerable impurities, the results obtained with different samples of rock salt differ often greatly. The secondary reactions may cause oxidation, that is, chlorate formation, or, on the other hand, reduction of the hypochlorite to chloride. The author has thoroughly studied the reactions in Schuckert's apparatus. Reduction is caused by reconversion of the hypochlorite into chloride, and takes place when the previously produced hypochlorite comes into contact with the hydrogen at the cathode, which at the moment of losing its electrical charge is in a very active condition. One method of preventing the reduction is the addition to the electrolyte of salts which, when their cations are yielded up at the cathode, form insoluble hydroxides, which act as protective diaphragms. As a matter of fact, it is not always necessary to add these salts, as they frequently occur as impurities in the salt employed to make up the electrolyte. The author recommends that the efficiency of each electrolyzer should be checked by drawing a curve with chlorine strengths plotted as ordinates and times of electrolysis as abscissae. By means of such curves it can be shown when any of the electrolyzers are not giving normal results. It is also important to give constant attention to the temperature and the alkalinity of the liquor. It is necessary to keep the temperature low, and the alkalinity should also be very slight, such that 1 litre of the solution when colored with phenolphthalein shall have its color discharged when two drops of normal acid are added. In any case, before employing the liquors for bleaching, the alkalinity should be neutralized. Some authorities prefer to have magnesium chloride present, but the author considers its presence objectionable, as it produces heavy deposits upon the cathode, which set up a resistance and impede circulation of the solution. He considers that the anodes, at any rate, should be of platinum, which if the metal is polished, is very little acted upon even when employed for a long time.

Copper Refining.—In an article by J. B. C. Kershaw in the *London Electrician*, June 5, reference is made to a process of H. G. Dolphin for improving the circulation and aeration of the electrolyte in the copper depositing vats, which is stated to have recently been installed in several British refineries. "Siemens & Halske use compressed air for agitating and aerating the electrolyte, while Dolphin makes use of the force of gravity and causes the electrolyte as it enters the vat to draw in with it the requisite amount of air. The advantages of this method of feeding the vats are stated to be as follows: The electrolyte is always of one density throughout the vat, and an absolutely steady motion is given to the liquor entering the vat from the feed tube. The silver slimes are not disturbed, and the cathodes do not contain more than $\frac{1}{2}$ oz. of silver per ton of copper. The iron in solution is oxidized and is precipitated with the other impurities on the floor of the vat. The cathodes are practically free from nodules, owing to the air bubbles which form on their surface being constantly removed by the friction of the electrolyte. The possibilities of short-circuits are minimized."

Iron and Steel.

Boiler-Plate Steel.—A paper by Charles L. Huston, published in the May issue of the *Journal of the Franklin Inst.*, discusses the leading tendencies in the manufacture and use of steel for steam boilers, bridges, etc., namely, the constant effort on the one hand to secure a material of higher tensile strength for carrying higher pressure or heavier loads with, on the other

hand, continual vigilance on the part of those upon whom the responsibility of the public safety rests, to require evidences of ductility in the material to avoid the danger point which is approached when the increased tensile strength called for reaches the stage where brittleness results. The author has investigated the general soundness and structure of some of our standard boiler steel ingots, bisecting them vertically and investigating them with a microscope and by chemical analysis, also by rolling some of the half ingots down into plates. The results are given in tables and diagrams, and it is shown that the general character of the segregation in the wide range of sizes and shapes of ingots tested is the same. "As the steel cools in the mold a steadily thickening wall of solidified metal forms against the sides of the mold (which is usually of cast-iron) and numbers of gas bubbles form and rise to the surface in the liquid portion, causing a rising current of metal adjacent to the solidified wall with return downward current in the center. This causes thorough mixing of the portion remaining liquid, but as the carbon and other elements are expelled from the solidifying wall the central liquid portion continually gains in these elements. This action continues until the temperature of the liquid portion falls to a point where its consistency becomes so thick that the gas bubbles cannot rise through it, when circulation ceases, gas formation ceases and segregation ceases and the metal inside this zone of gas bubbles solidifies in a mass of comparatively uniform character." The greatest degree of segregation in the transverse axis of the ingot is adjacent to the zone of gas bubbles, the carbon which was last expelled from the solidified metal being held in the adjoining portion of the central mass of metal which was at the time of too thick consistency to circulate and distribute it, the central vertical axis having less carbon than this gas bubble zone except near the top. Hence, the specimens of plate steel for testing, which, as a rule, are taken from shearings from the outer margin of the plates as rolled, show the softest part of the metal, so that there is much harder metal in the interior. This brings about a very risky state of things. "It would be well if some plan could be adopted now and put into general use which would automatically encourage the use of soft, ductile metal, thus securing increased safety to the traveling public and doing away with a lot of difficulty and contention between makers and the inspectors who represent the users of the metal; whose rejection of quantities of material often occurs simply because it falls slightly below the required minimum limit, though this material, because of its greater ductility, can withstand being worked into the required form for the finished boiler with less risk of weakness developing, and is more worth of carrying the required unit stresses under conditions of service than would be a harder metal of the same thickness. Under present general engineering practice the working stresses allowable are based entirely upon the minimum tensile strength shown, ductility and maximum tensile being introduced only as a check. It would be far better, I believe, if the ductility were introduced as a factor in conjunction with tensile strength to determine the allowable working stresses so that a somewhat lower tensile steel may be used, where it shows a corresponding increase in ductility. In fact, I believe it would result in great improvement over present practice, first, to determine the maximum unit stress and then specify the range of tensile stress allowable in the steel, coupled with a corresponding proper ductility, showing, for instance, given a maximum unit stress of 12,000 lb. per square inch for one class of service specify that the steel shall be allowed a range from 50,000 to 60,000 lb. T. S., provided it also shows a ductility of 1,500,000 lb. divided by the actual T. S. in pounds. This would result in a factor of safety of five with steel of ordinary ductility, but where the ductility showing is high permit a somewhat less factor of safety, and thus encourage the use of soft steels, which, judging from experience of many years, would result in far greater safety to the public service." These suggestions are applicable only to material to be used in tension.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Machining Amorphous Carbon Articles.—P. McN. Bennie, 889,081, June 9, 1907. Assigned to National Carbon Co.

Ordinarily articles of amorphous carbon are difficult to machine owing to the hardness and brittleness of the material. In order to make machining more easy, the inventor softens locally those parts in which the machining tool is to operate without affecting the other portions of the article. For that purpose he causes an arc to play upon the surface of the hard amorphous carbon article from a stationary electrode and manipulates the carbon article, presenting it to the stationary electrode in such manner that the arc locally softens or graphitizes the hard amorphous carbon in those portions or parts which it is desired to remove. The application of this method to forming screw threads is described. Only these parts of the article which are to be machined are thereby graphitized and softened, while the bulk of the article retains the original qualities of the amorphous carbon, especially the high thermal resistance and its physical strength.

Electrolytic Furnaces.

Baryundum.—R. Battistoni and R. Rotelli, 888,956, May, 26, 1908. Appl. filed Jan. 14, 1905.

"The product "is composed of a mixture of 10 to 12 per cent BaC_2 , 3 to 5 Ba(CN)_2 , 80 to 85 BaO . This product of oxycarbide of barium is designated by the name of baryundum. It is distinguished from BaC_2 , as well as from BaO , by its color, its crystalline structure, the easiness with which it is dehydrated and the disengagement of NH_3 , which is effected by the hydration of Ba(CN)_2 ." This product is obtained in an electrolytic furnace by electrolyzing with direct current molten barium carbonate to which are added 3 or 4 per cent of exceedingly finely divided carbon. "The carbon acts as a catalytic substance, as a conducting means for the electric current and offers a whole system of bearing surfaces for the regular development of the ions freed by the current." The furnace is first used as an arc furnace, but when the charge is molten the upper electrode is lowered and the furnace is used as resistance furnace. The action is claimed to be that the current decomposes the BaCO_3 into BaO and CO_2 . The presence of carbon bases rise to the formation of BaC_2 . The latter is a strong reducing agent and a certain quantity of Ba(CN)_2 is formed. It is recommended to add to the charge 5 or 6 per cent of a mixture of alkaline salts, as for instance those which are obtained by calcining the mother lyes obtained in the extraction of sugar from the molasses. These salts act as a flux powder.

Electrolytic Processes.

Tin Refining.—O. Steiner, 890,249, June 9, 1908. Application filed Aug. 10, 1907.

The third claim refers to "the method of obtaining tin from crude tin or tin alloys which consists in treating the impure tin as an anode in an electrolyte composed of an alkaline sulfid solution, depositing the tin upon a cathode having a pure tin surface, maintaining the tension between the electrodes at less than 0.2 volts, and keeping the electrolyte quiescent in order to avoid disturbing the mud deposited in the bottom of the bath, removing the anode residues, regenerating the electrolyte by adding sulfur thereto and reusing it to electrolyze fresh anodes." This process of refining tin was described by Dr. Steiner in full in our Vol. V, page 309.

Copper Deposition.—L. Amenabar, 890,887, June 16, 1908. Application filed Nov. 4, 1907.

A sulphuric acid solution of copper is circulated through a system of tanks in which the copper is precipitated in an incoherent granular or flocculent form by using a sufficiently high current density. "Practice has demonstrated that a cur-

rent of 200 amperes and approximately 5 volts per square foot of electrode gives excellent results, both as to economy in time and current consumption." Under these conditions any deposit on the cathode will be of such nature that it may be readily dislodged by shaking the electrodes, washing them, circulating the electrolyte or by a light scraper; when dislodged, the precipitate will pass out of the electrolytic tank with the liquor. The anodes are made of lead or carbon, the cathodes of copper or lead.

Copper Deposition.—M. A. Jullien and E. L. Dessolle, 884,021, April 7, 1908. Application filed April 4, 1907.

Absolutely homogenous copper which has the same resistance and the same tensile strength in every direction and is especially suitable for tubes, plates, etc., is obtained by electrolytic deposition on a revolving cylinder. By special apparatus a polishing action is imparted to the deposit during formation.

Concentrating Nitric Acid.—H. Pauling, 887,226, May 12, 1908. Application filed Aug. 13, 1906.

Dilute nitric acid is subjected to electrolysis in a diaphragm cell and the nitric oxides formed at the cathode are supplied to the anolyte in which they dissolve and are oxidized by the oxygen generated at the anode so as to form nitric acid. The reaction is expressed by the equation $\text{N}_2\text{O}_3 + \text{H}_2\text{O} = 2\text{HNO}_3$.

Aluminium Oxide.—F. W. Morris, 890,084, June 9, 1908. Application filed March 13, 1907.

The object is to produce pure aluminium oxide from clay, etc. The material containing the aluminium, with its common impurities, is first treated with sulphuric acid to form sulphate of aluminium in the same manner as is commonly practiced in the production of alum. The sulphate of aluminium with such of the impurities as are soluble in the acid, is then charged into the anode compartment of an electrolytic cell, the cathode compartment of which is charged with a saturated solution of a chloride of an alkali metal, such as sodium or potassium, the hydrate of which will, when in excess, dissolve aluminium hydrate. The anode is made of platinum or graphite, the cathode of iron. Chlorine is evolved at the anode and alkali hydrate is formed at the cathode with evolution of hydrogen gas. The aluminium and other bases forming impurities of the clay are transposed to the cathode compartment by electrolysis and under the action of the hydrate therein form hydrates of themselves. The hydrates of the iron and other impurities being insoluble in the alkali hydrate are precipitated. The aluminium hydrate which is soluble in the excess of alkali hydrate present under this process, is dissolved and forms an aluminate of the alkali used. The solution of aluminate of the alkali is then siphoned off from the cathode compartment, evaporated to dryness and calcined. This product is then lixiviated in any approved manner to recover the alkali leaving the pure oxide of aluminium as the desired product. The sulphuric acid which has been used to dissolve the aluminium and other bases, and which remains in the anode compartment, is available for treating a further charge of the clay."

Electroplating Apparatus.—W. R. King, 888,093, May 19, 1908. Application filed Dec. 15, 1905; assigned to Hanson & Van Winkle Co.

For plating a large number of small articles, a containing drum of perforated wood is generally used. If the perforations in the wood are too small, the resistance is too high, while if the perforations are too large there is liability of small articles falling out of the drum. The inventor uses a wooden drum with very large holes and in it, a thin, flexible diaphragm of celluloid, vulcanite or the like, about 15/1000-in. thick. It is so arranged that this diaphragm may be slipped into the wooden drum in a convenient way. This diaphragm has a large number of very small holes.

Electroplating Apparatus.—J. T. Daniels, 888,968, May 19, 1908. Application filed July 29, 1907. Assigned to Hanson & Van Winkle Co.

If a number of small articles are to be plated within a re-

volving drum, the inventor uses as cathode a weight suspended by a chain from the shaft in the center of the drum. The articles to be plated surround the weight and chain, and, therefore, make efficient contact with them.

RECENT METALLURGICAL PATENTS.

Iron and Steel.

Dephosphorizing Ore.—J. T. Jones (890,230, June 9, 1908) patents a method for dephosphorizing and reducing iron and manganese ores in one continuous operation. The process is based on the following two observations: "First, when iron or manganese ore is subjected, for a time sufficiently prolonged and while under confinement against access thereto of oxygen, to the action of a hot reducing gas and raised thereby to a temperature which will render the metal constituent sufficiently plastic, without however fusing the silicious constituents, the oxide particles are reduced to metal and caused to agglomerate, forming what may be characterized as sponge. Second, that as the temperature to which the ore is required to be subjected for the above purpose does not reach that necessary to bind phosphorus to the metal, volatiles freed from hydrocarbon fuel by the decomposition thereof and passed through the ore undergoing reduction will readily combine with any phosphoric acid in the ore and carry it off." The process is carried out in a stack furnace into which the ore is charged at the top. The reduction and dephosphorizing goes on in the lower part of the stack, through which a reducing gas is passed upwards (without access of air) from a gas producer. Air is blown into the stack at the top in order to burn the gas and preheat the fresh ore charged into the furnace.

Tungsten Steel.—If tungsten is embedded into steel by throwing tungsten powder on top of the molten bath in an open-hearth furnace, considerable losses are experienced. P. Kemery (887,648, May 12, 1908), recommends to introduce the tungsten or other metal into the bath by enclosing the tungsten powder in a thin steel tube and when this tube is thrown into the furnace just before casting, the tube sinks to the bottom of the bath and the tungsten dissolves in the molten bath.

Precious Metals.

Removal of Gold, Silver and Platinum from Lead Alloys.—

A patent of W. Morrison (890,160, June 9), refers to a process for removing within a few hours gold, silver, copper and platinum from lead alloys. The lead alloy of precious metals is placed with zinc and with potassium cyanide as a flux into a crucible and heated to a dull red heat until the zinc approaches the point of volatilization. The heat is then shut off and the crucible cooled, whereby the zinc and precious metals separate from the lead and rise to the top. If the object is to remove the gold only and if no platinum is present, the material with or without the lead (which is at the bottom and can be easily broken off or cut away) is treated with strong nitric acid, which dissolves everything except the gold and lead. The gold is obtained in powdered or granular form separate from the lead. If it is desired to remove both the gold and platinum, the material from the crucible is treated with concentrated sulphuric acid, which dissolves silver, zinc and copper. After washing with hot water and removing the lead mechanically, the remaining material is treated with a dilute solution of nitric muriatic acid, which dissolves the gold and leaves the platinum. Or a potassium cyanide solution may be used. If it is desired to recover the gold, silver, copper and platinum, the material from the crucible is covered with hydrochloric acid or dilute sulphuric acid. This dissolves the zinc leaving all the gold, silver, platinum and copper in powder or granular form, and the lead as solid metal. The acid with the zinc is washed off and just enough nitric acid is added to the residue to dissolve the copper and silver. The silver is precipitated with hydrochloric acid, the solution poured off, the residue washed and

the copper precipitated with oxide of calcium. The platinum and gold are then separated as before described.

Miscellaneous.

Valve-Seat Alloy.—An alloy suitable for valve disks, seats or packings, is made, according to H. W. Wortche (887,473, May 12, 1908) of 90 per cent lead and 10 per cent antimony. For a hard composition that will withstand the action of steam, oil, acids, alkalies, etc., at high pressure and at an elevated temperature, an alloy of 80 per cent lead and 20 per cent antimony is preferred.

Antimony.—A patent of J. R. Masson (890,432, June 9, 1908) describes a process for the recovery of pure antimony from ores, concentrates, tailings and slimes. Pulverized ore is treated with a solution of caustic soda or potash, and the antimony is thereby extracted. Sulphuric acid is then added to the solution thereby precipitating antimony sulphide. The precipitate is mixed with clean sand and chloridized by a stream of chlorine gas. The antimony chloride is washed out and the strongly acid liquor is run into vats containing pieces of iron. Pure antimony is thereby precipitated.

On account of limitations of space a large number of abstracts of patents and articles had to be reserved for the regular departments in our next issue.

Blast Separator, Gas Scrubber and Dust Collector.

The Osborne pneumatic blast separator, built by the Osborne Engineering-Manufacturing Company, of New York City, and shown diagrammatically in the adjoining illustration, is designed for separating the fines from the tailings and for screening all classes of pulverized material, the separation being regulated to any degree of fineness desired, ranging from 40 to 200 mesh.

In the operation of the machine the material to be separated is fed through a chute and falls upon a rotating disk. The centrifugal force throws out the material, thoroughly scattering it and giving it a whirling motion. A blast of air is simultaneously blown through the material while in suspension, separating the fines from the coarse, throwing the fine material or finished product by short circuit into the dust-collector, where the material is separated from the air, while the air is returned back to the fan to be again used in separating the material.

The air is forced into the separator by means of a blast fan through an air inlet at the bottom. Within the air inlet is mounted a feed disk journaled upon a shaft in a bearing and rotated by bevel gears connected with a pulley which is actuated by any suitable source of power. The gears are enclosed in a casing to protect them from dust. Directly above the disk is an inlet pipe through which the material to be separated or graded is introduced.

A trunk extends downwardly from the bottom of the separator casing and is provided with interior partitions between which and the walls of the trunk, passages are formed adjacent to the side of the trunk. The lower end of the trunk is provided with an outlet for the tailings, and an air-blast pipe enters the trunk and directs a current of air upwardly through the air inlet.

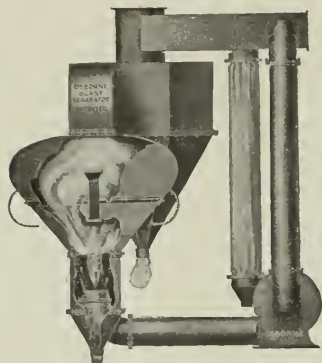
When the separator is in operation the feed disk is rapidly rotated and throws the material delivered by the feed pipe across the air inlet where it is entertained by an upward blast of air and raised into the casing of the separator. The dust and finer particles are immediately carried away into the dust collector by a current of air, while the heavier particles fall direct through the tailing spout or remain suspended for a while in the air current, until they finally come in contact with the walls of the separator, slide down the walls and escape through the outlet.

The degree of fineness of separation can be very easily regulated by adjusting the width of the air-blast passage and therefore the velocity of the air blast (the volume of air blown remaining constant). For this purpose the separator is provided

with two adjustable walls pivoted at their lower extremities and provided with adjusting rods which are pivoted to the walls at their inner ends and pass out through slots in the outer walls of the casing. Teeth on the lower sides of the adjusting rods normally engage the lower ends of the slots so as to hold the walls in adjusted position, and covered plates sliding inways on the walls closely embrace the rods and prevent the escape of air or dust.

When it is desired to adjust the walls, the outer ends of the rods are raised together with the slides, so as to disengage the teeth, and the rods may then be pushed in or pulled out. By this adjustment the width of the air passage between the walls of the separator is varied, and thus the velocity of the air current at this point is varied, and the separator may be made to grade material to different degrees of fineness. When it is desired to carry only the fine particles into the dust collector, the walls are moved apart so as to increase the space between them and reduce the velocity of the air current, and under these conditions only the finest particles will be sustained by the air current and carried into the dust collector. When it is desired to carry the coarse particles into the dust collector, the walls are adjusted closer together.

As has already been mentioned, the number of cubic feet of air used per minute and its carrying capacity remain the same, whatever its adjustment. This is the chief reason for the very



PNEUMATIC BLAST SEPARATOR.

large capacity of the Osborne separator in handling a very fine powder.

The relative arrangement of the separator, dust collector and the blower, is such that no material is passed through the blower. The material is delivered to the air blast after it issues from the blower, and is entirely abstracted from the air by the separator and the dust collector before the air is returned to the blower from the latter. This feature is novel in a closed pneumatic separating system, and it is a feature of importance where the material to be operated upon is of an abrasive character, such as might injure the blower by violent contact with the rapidly moving blades, or of a character which would tend to cause it to clog the casing of the blower or to collect upon the arms thereof.

The air pipe which conveys the air from the dust collector back to the fan is provided with equalizing vents connected with cylinders of wire gauze or flume cloth to prevent the escape of dust. The object of these vents is to permit the entrance or escape of air when necessary to equalize the air pressure within and without the apparatus.

It is to be noted that these air vents are so located that the air separator is caused to operate by means of a blast of air under pressure as distinguished from a current of air produced by suction as in other previously proposed devices of this charac-

ter; that is to say, any vacuum in the air pipe will be then neutralized by the entrance of air through the vents. This is a feature of importance in the construction and conduces to a successful operation of the apparatus.

As material is introduced through the feed pipe and accumulated in the separator, it causes a back pressure and accumulation of air between the blast pipe and separator owing to the resistance offered by the body of material in the separator to the passage of air therethrough, and this results in a partial vacuum in the air pipe and an inflow of air through the vents to restore an atmospheric pressure in the air pipe.

In diminution in weight of material suspended in the separator a reverse action takes place; that is to say, the pressure between the blower and the separator diminishes and an outflow of air occurs at the vents, whence, it is to be seen, that these vents operate as a governor of the amount of air used in the system preventing a congestion of air as may be experienced with separators of the vacuum type.

The manner in which the air is delivered to the separator creates very little friction only, and consequently, requires but little horse-power to separate a ton of finished product. It is found that the average horse-power consumed does not exceed 2 hp per ton of finished product per hour.

Each machine is built large enough to handle a class of material 200 mesh fine, the size of the machine being governed by the number of pounds to be separated per hour and the degree of fineness desired.

For the reasons stated above the Osborne separator is very suitable for handling all classes of abrasive material, such as cement, phosphate rock, limestone barites, etc., where a degree of fineness ranging from 50 to 200 mesh is desired.

The drier the material the better is the separation. But it is a fact that Osborne separators are handling in practice material containing 10 to 12 per cent moisture without any trouble. Thus, the Aluminum Company of America have five Osborne separators installed at their East St. Louis plant, where they are separating bauxite containing 10 to 12 per cent moisture. The average capacity of each machine is eight tons per hour of finished product that will screen 90 to 100 mesh fine.

Another very good machine of the Osborne manufacture is the Osborne water spray gas scrubber and dust collector. This machine is largely used in manufacturing plants throughout the country to do away with the smoke nuisance. Not only is the smoke nuisance abolished by it, but all the carbon in the smoke is collected and saved and may be used in the furnaces.

Other uses of this machine are for the collecting of the fine dust from calcining furnaces, and for the washing and collecting of gases from roasting ovens in concentrating plants, leaving the air escape into the atmosphere in a practically pure state.

Osborne gas scrubbers have been installed at the works of the Aluminum Company of America, East St. Louis, Ill.; the S. D. Warner Paper Co., Cumberland Mills, Maine; the Pennsylvania Salt Manufacturing Co., Natrona, Pa.; the Springfield Gas Co., Springfield, Mass., and in many other large plants.

Missouri River Development.

The Missouri River power development is an interesting example of progressive engineering activity in the Western mountainous mining and metallurgical country.

Over twelve years ago a wooden dam was built across the Missouri River at Cañon Ferry, by the Helena Power Transmission Co., Helena, Mont., and the impounded waters used to operate four 750-kw turbines direct connected to electric generators. The voltage of the alternating current from this station was stepped up to 11,000 volts and transmitted 18 miles to Helena to be used in the mines and smelters there.

From the very first the enterprise proved a success. The original company, later enlarged and reorganized as the Missouri River Power Company, undertook to transmit power to

Butte, 80 miles away, for use in the mines in that section. To this end six new 750-kw generators with their water-wheels were added to the original equipment. The first transmission line, using as high as 50,000 volts, was built from Cañon Ferry to Butte and was very successful. In completing this plant the waters of the river were backed up for 18 miles, giving a fall of 30 ft. at the dam.

As the demand for power grew, the present company, the Helena Power Transmission Company, was formed, taking over the equipment of the older companies and building a new dam below the Cañon Ferry at Hauser Lake, where four 2800-kw waterwheel-driven alternators were installed.

Power from these plants is carried over double lines to Helena, Butte and Anaconda, the last named place being over 100 miles from the generating points. Practically 16,000 horsepower is used to operate the mines at Butte. The Helena Street Railway system is operated from this source and the Great Washoe smelter of the Anaconda Copper Company at Anaconda is another heavy consumer.

The electrical equipment of this great smelter, built by the Allis-Chalmers Company, Milwaukee, is unique among all plants of its kind so far built in that it includes four of the largest induction motors installed west of Niagara and was the first smelter in the country to be driven by electric power exclusively. The concentration building is 600 ft. long. The jigs, tables, etc., are driven from a main-line shaft 500 ft. long. Two induction motors are installed in each half of the mill and connected to the main shaft by rope-drive and friction-clutch pulleys. Each motor has an output of 1200 horse-power at 360 r.p.m. synchronous speed. Connection is made to the main shaft by 18 2-in. ropes.

These large motors are notable not only on account of their large capacity, but also because of their having squirrel-cage rotors, something unusual in motors of this size. Their guaranteed full-load efficiency is 91 per cent and full-load power factor 92 per cent. Squirrel-cage motors were chosen for this installation because the conditions under which they have to start are favorable and also because of the higher power factor of this kind of motor as compared with the wound rotor type.

In addition to the four large motors there is also provided a 200-hp, variable-speed, 60-cycle, 2080-volt induction motor for operating the pumps in the mill.

This motor is of standard type with wound rotor and collector rings for the insertion of resistance in the secondary. The normal speed is 450 r.p.m. and can be reduced to 225 r.p.m. by means of a grid type resistance furnished with the motor. Allis-Chalmers Company has also furnished for this plant three synchronous motor-generator sets of 300-kw output each, and one small induction motor-generator set for starting and exciting the synchronous sets. The 300-kw sets are driven by 12-pole, 2080-volt, 60-cycle synchronous motors and run at a speed of 600 r.p.m. The direct-current generators for these sets are compound wound for 550 volts and are easily able to carry 50 per cent overload for two hours without heating more than 55 deg. C. and without sparking. At normal full load the temperature rise does not exceed 35 deg. C in any part. The sets have three bearings and the stator of the synchronous motor is arranged to slide sideways on the base to give access to the field and armature windings. These units are to operate crane motors throughout the plant and also furnish power for other purposes.

Formerly all the power required by the Washoe smelter, which has been equipped throughout with electric drive, was obtained from steam engines, and a certain amount of steam power will probably always be used, as some of the steam boilers utilize the heat contained in the waste gases from the furnaces. However, this power, obtained as a by-product, is not nearly sufficient to operate the whole plant, and all additional power is now supplied as above stated by current transmitted from the Missouri River.

Columbia University.

Mr. Arthur L. Walker, who retired on January 1, 1908, from his connection with the American Smelting & Refining Company as consulting engineer and member of the Board of Directors, and has since been engaged as general consulting engineer in New York City, has been appointed professor of metallurgy and administrative head of the department of metallurgy at Columbia University. His duties will begin on July 1, and he will take personal direction of the instruction in non-ferrous metals and electro-metallurgy and metallurgical design. Mr. Walker is one of the most distinguished metallurgical engineers of this country.

Prof. Henry M. Howe will continue to deliver his lectures on iron and steel, as heretofore.

In 1907 Columbia University revised the entrance examination requirements for its Schools of Mines, Engineering and Chemistry by co-ordinating them with the programmes of the best secondary schools. By the adoption at the same time of a uniform programme of studies for the first year in all courses students were no longer compelled to make up their minds at the outset as to the particular course they desired to take. Following these steps has come the co-ordination and revision of the three subsequent years of each of the courses. This revision will go into effect on July 1, 1908.

In the first place, the programmes have been thoroughly co-ordinated by cutting out such duplication of instruction as had grown up in the development of the several departments.

Secondly, the work in many subjects has been made more intensive, and, as a result, it has been possible to reduce the total number of attendance hours in such courses.

Thirdly, new courses have been arranged in gas power and steam power machinery, and exercises in alternating-current laboratory practice have been introduced in the third year of the course in mining engineering. This work has also been introduced into the course in metallurgy, and, in addition, work in mining law and in hydraulics.

A New Manganese-Silicon Alloy.

Silicon and manganese—the two chief and most effective elements used as a “physic” in the steel industry—have generally been employed in form of ferrosilicon, ferromanganese, spiegeleisen or silicon-spiegel. If made in the blast furnace, these alloys (with the exception of ferromanganese) cannot be produced with a high percentage of the desired element. Blast-furnace alloys also contain a large percentage of carbon.

Only with the advent of the electric furnace the production of high-percentage ferroalloys, very low in carbon, has become possible. But although ferrosilicon and ferromanganese, containing as much as 90 per cent of silicon and manganese respectively, have been produced, thus enabling the steel-maker to introduce a desired amount of these elements into the steel in the smallest bulk, it has not in actual practice been found desirable or economical to use ferrosilicon over 50 or 60 per cent or ferromanganese over 80 per cent; consequently, when it is desired to add any considerable amount of manganese or silicon to the steel, it is necessary to add a somewhat large quantity of these alloys to the bath or ladle.

These large quantities of additions exert an appreciable chilling effect on the metal when made in the ladle after tapping, or, on the other hand, when made in the furnace, the loss by oxidation is large. This loss is most pronounced and serious in the case of the manganese, and it therefore becomes necessary to add a large excess, which, besides being expensive, raises the carbon in the steel.

To overcome these difficulties there has recently been put on the market by Messrs. Roberts, Evans & Woodhead, of Liverpool, England, a high-grade ferrosilicon-manganese alloy which is a product of the electric furnace, and deserving of a more extended use than has hitherto been accorded it. The alloy

can be obtained in several grades, and in such a high state of purity as regards carbon, sulphur and phosphorus as is highly desirable from the steel-makers' standpoint.

The following are a few typical analyses of the material delivered at more than one steel works:

Silicon.....	24.90	25.02	28.50	25.51
Manganese.....	67.73	68.64	63.45	66.26
Phosphorus.....	0.091	0.021	0.065	....
Carbon.....	0.170	0.160	0.150	0.180
Sulphur.....	0.012	0.010	0.019	....

It will be readily understood that in cases where it is desired to add both silicon and manganese to the steel a very much less quantity of alloys has to be added to the metal in ladle or bath. The use of the ferrosilicon-manganese alloy presents the further advantage that in addition to being practically free from carbon and other impurities, only half the quantity of these impurities are introduced to the steel, as compared to the case of separate additions of ferrosilicon and ferromanganese, even if it were possible to obtain those alloys of an equal degree of purity.

It is worthy of note that the decreased amount of alloy necessary in the case of the ferrosilicon-manganese is not due only to the fact that the silicon and manganese are combined with a smaller amount of iron, but also due to the fact that the loss of manganese, due to oxidation, is also very much less. The silicon acting as an energetic deoxidiser is first attacked by the occluded gases in the steel, and consequently the manganese is practically all retained by the metal, instead of going to the slag, as is the case when ferromanganese and ferrosilicon are added separately.

Some experiments were recently carried out in open-hearth furnace to determine to what extent the oxidation loss was reduced, and it was found as a result that, when using the new alloy, although the loss of silicon was practically the same, the loss of manganese was only about one-third of what it was when adding the silicon and manganese alloys separately. For instance, in one case, ferrosilicon-manganese was added to a charge in such quantity as to theoretically give 1.035 per cent of manganese in the metal. The finished steel on analysis gave 0.946 per cent of manganese.

Another charge worked under exactly similar conditions as to time and condition of slag, and from the same pig iron and scrap, had added to it ferromanganese in quantity to give almost exactly the same theoretical amount of manganese (1.05 instead of 1.035) together with an amount of ferrosilicon containing a similar quantity of silicon to that contained in the ferrosilicon-manganese alloy used in the other charge. The finished steel on analysis gave only 0.82 per cent of manganese, showing a loss of 22 per cent against only 8.4 per cent in the charge where the new alloy was added.

It is found that the silicon not only protects the manganese from oxidation, but that its action on the metal is very much more complete, giving good solid metal, quite free from all blow-holes. The result on the finished material is also appreciable in the results of the physical tests, the ductility especially being improved, and this at a reduced cost for "physic." The results of careful and extended trials in the use of the new alloy for the manufacture of steel castings, forgings and tyres, and miscellaneous material for special purposes, show that, taking the prices of the various alloys, there appears to be a substantial saving in favor of the use of the ferrosilicon-manganese alloy.

The silicon-manganese alloy is specially suitable for use in the manufacture of steel castings, forgings and tyres, plates and bars, and all similar materials in which it is desired to obtain the maximum soundness, toughness and resistance to wear and abrasive action. The high degree of purity in which it is put on to the market enables it to be used in the production of the very finest special steels, more particularly mild steel.

Water Sterilization for House Use.

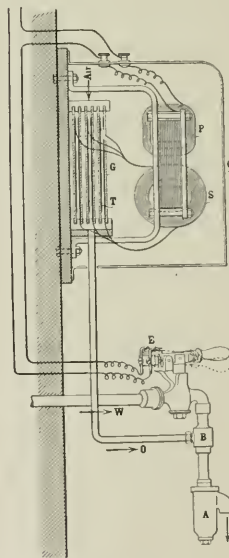
In a recent issue of *Lond. Electrical Engineering*, we find a description of a commercial apparatus sold in England by the Lahmeyer Electrical Company and called the Otto ozonizer. The apparatus is of the type used for installation in private houses for treating the drinking water instead of filters, and consists of a small transformer and ozonizer enclosed in a case a little over a foot square. A special tap and emulser in which the ozone is mixed with the water are also provided. If the supply is continuous-current, a small rotary converter, four or five inches in diameter, must be used to convert to alternating current. The principle of the ozonizer is best explained with the aid of the adjoining diagrammatic sketch.

In the upper part of the sketch are shown the transformer and ozonizer in the metal case. P is the primary winding of the transformer, which is supplied with current at from 100 to 250 volts, according to the voltage of the supply mains or the converter. S is the secondary winding of very fine wire, which supplies current to the ozonizer plates at a pressure of about 15,000 volts. The ozonizer proper consists of six or more glass plates (G) supported on a grooved bracket at the bottom, and by grooved slips at the top and sides. Three pairs of plates are shown in the sketch. The inner sides are each provided with a coating of tin foil (T), the opposing coatings being connected in parallel with the secondary winding of the transformer. The distance between the coatings is about one millimeter, and the layer of air is broken down so that a continuous brush discharge takes place between the coatings. The oxygen in the air passing between the coatings is converted by the action of the brush discharge into ozone.

The air enters at the top and sides of the battery of plates, and is sucked down through the opening provided in the lower bracket into the ozone pipe by the action of the water at the junction B. The water carries the ozone down with it into the emulser A, in which the two are mixed together and the water thoroughly sterilized. As the transformer need be working only when water is being drawn, the primary switch is interconnected with the water tap as shown at E in the sketch. When the water is turned on, the primary winding, or, in the case of a continuous-current supply, the converter, is connected to the supply mains and in a few seconds thoroughly sterilized water is issuing out of the emulser at the rate of 60 gallons per hour. As the apparatus requires little more power than that corresponding to the no-load losses of the transformer, the consumption of energy is very low.

When first drawn, the water smells strongly of ozone, but in a few seconds the ozone has gone, leaving the water fresh and pure. The apparatus is said to supply some 8 to 10 grains of ozone per cubic meter of air, although much less would be sufficient to perfectly sterilize the water with which it is brought in contact.

It is stated that in several French towns the Otto system of sterilization of water by ozone has been or is being adopted



on a large scale. In this case the ozone is pumped into mixing tanks and these are filled with pebbles in order to insure that the water is thoroughly broken up and mixed with the ozone. Some of the larger installations are stated to deal with several millions of gallons of water daily.

Equipment of a Large Zinc Oxide Plant.

The oxide plant of the Ozark Zinc Oxide Works, at Coffeyville, Kan., said to be the most complete of its kind in the West, had a capacity of 60 tons of ore per day, later increased to 125 tons of ore per day, and is adapted to the manufacture of either zinc oxide or leaded zinc. The plant, which was extensively enlarged in 1907, uses a modification of the old Wetherill process and, being divided into two separate units, one can be employed independently of the other. Since the Ozark Company is controlled by the Sherwin Williams Company, paint and varnish makers, of Cleveland, Ohio, its output of pigments is very largely used in the Cleveland company's product.

Ore is unloaded from the mine car into a 20-in. x 10-in. Blake crusher which discharges into a Gates elevator and is carried to the top of the building and discharged into a revolving screen, having $\frac{3}{8}$ -in. openings, the oversize from which goes to a set of 36-in. x 12-in. crushing rolls on the second floor. The $\frac{3}{8}$ -in. material is discharged into a second trommel with $\frac{1}{4}$ -in. openings, the oversize going to another set of 36-in. x 12-in. crushing rolls on the first floor, after which it is returned to the crushing rolls on the second floor, after passing to a mixing drum which discharges into a Vezin sampler. The crushing machinery, including elevators and screens, was furnished by Allis-Chalmers Company, Milwaukee. A 75-hp induction motor drives the crushing section. Storage bins for crushed ore are arranged to be emptied from beneath into cars.

The roasting is done in two five-hearth Allis-Chalmers McDougall furnaces, each 18 ft. x 16 ft. 6 in. high, and driven by a 25-hp induction motor. At a later date two six-hearth McDougall furnaces were added, each 18 ft. x 19 ft. high. They are fired by gas, ordinary 1-in. x 2-in. mixers being used for the furnaces. These furnaces have a capacity of from 25 to 35 tons each per day, but the question of capacity can only be approximated on a new proposition.

The composition of the ore is not a true index to its calorific values. Two ores may be of the same general composition and yet be at great variance in heat values contained, or the amount of heat necessary to be added in order that they may be roasted to a given percentage in sulphur. For example, the Butte ores have the same general characteristics one with another, yet the roasting capacities of these furnaces varies with the different plants. At one place where there are 20 McDougalls installed the amount of ore treated per furnace is 35.9 tons of wet material, 9.7 moisture, and roasted down to 8 per cent in sulphur. At another plant where there are two furnaces installed working under almost identical conditions, they are roasting only 30 tons. This reduction in tonnage is principally due to the combination of the sulphur contents.

In the furnaces installed at Coffeyville, the ore is taken from the bins in two-ton cars, is elevated to the tops of the furnaces and discharged into the large hoppers from which the furnaces are fed. The ore deposited automatically onto the roasting hearths, passes through the furnace and after roasting is discharged into cooling bins from which it is taken to the oxidizing furnaces. After roasting the sulphur content of the ore is reduced to 3 per cent only.

There are two blocks of oxidizing furnaces each containing 18 furnaces 6 ft. x 12 ft. The blast is furnished by two fans driven by a 30-hp motor, is carried to the furnaces by a large underground conduit and discharged under the grate. The furnace is controlled individually by means of a drop grate.

The fumes are drawn away from the furnaces by a large ex-

haust fan located in the bag room. The fume first enters a combination chamber when the carbon is all burned out and the dirt is allowed to settle. It is then fanned through 600 ft. of cooling pipe to lower its temperature. Then it enters the fan and is driven to the bag room. The fume first enters the lateral pipe and from thence is distributed to 18 pipes each with 17 hoppers on which short bags are tied reaching to the floor. Oxide is shaken down into the short bags, which are removed every 24 hours and dumped into a conveyor which carries them to the packing room. Oxide is packed 400 pounds in a barrel.

The power plant comprises two 180-hp boilers fired by gas, and one 250-hp Corliss engine direct-connected to an Allis-Chalmers alternating-current generator of 150-kw capacity. The coal used is practically all Arkansas semi-anthracite. The design for this plant was laid out by Allis-Chalmers Company, Milwaukee.

Notes.

E. J. Lavino & Co., of Philadelphia, dealers in ores, metals and ferro alloys, have sent us a very useful brass-trimmed desk rule.

The Moechel & Lowther Engineering Co. have established a consulting office and testing laboratory for chemical engineering work at 1110 Wyandotte Street, Kansas City, Mo.

The American Process Company, manufacturers of mechanical drying apparatus for drying all classes of ores, chemicals, etc., have moved their offices from 62 to 68 William Street, New York City.

Radiation Pyrometer.—An interesting illustrated Franklin Institute paper by Dr. C. B. Thwing, published in the May issue of the *Journal* of this institute, discusses his new radiation pyrometer, which was described in our February issue.

Detroit Foundrymen's Convention.—A number of Detroit members of the American Foundrymen's Association recently held a meeting and formed the Detroit Foundrymen's Association. Mr. W. M. Corse, of the Detroit Lubricator Co., was elected president, Mr. A. P. Henry, of the Henry Standard Pattern Works, secretary.

Getting Ready for Prosperity—Under this suggestive title a booklet has just been issued by Dr. Fred. J. Maywald, consulting chemist and successor to the late Prof. Peter T. Austen. The booklet emphasizes that now is the time to get ready for prosperity and shows how the chemist can assist the manufacturers to do this. The book is sent to interested parties on request.

The Dow Chemical & Manufacturing Company, of Mansfield, Ohio, call attention to the fact that they are prepared to make all kinds of nickel castings for all purposes, and have in the past done considerable work in this line. Castings are made according to specifications and are not limited in size or shape. This company also furnishes complete electroplating outfits and supplies, including dynamos, tanks, anodes, chemicals and polishing machinery.

Oildag—Mr. E. G. Acheson has transferred to the Acheson Oildag Company his patents and trade-marks covering his latest important and valuable products—oildag and aquadag. Oildag has already obtained wonderful popularity as a gas engine lubricant, as its use makes possible a fifty per cent reduction in the oil consumption, at the same time greatly increasing the available power of the engine by decreasing the friction and increasing the compression, also quieting the engine and making it run like velvet. Thus it effects economy while improving results. Oildag is also valuable in the operation of electric lighting plants. It is a mixture of deflocculated, unctuous Acheson graphite mixed with oil, put up in tubes and cans for charging one, five and ten gallons of mineral oil. The Acheson Oildag Company has established offices and works at Niagara Falls, N. Y., and has elected the following officers: President, Mr. Edward G. Acheson, Jr.; secretary, Mr. W. H. Arison; treasurer, Mr. A. M. Williamson.

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

ELECTRIC FURNACES.—(Continued).

No. 236,478, Jan. 11, 1881, Clinton M. Ball, of Troy, and John H. Guest, of Brooklyn, N. Y.

Resistance type, for carbonizing electric-lamp filaments. The articles to be carbonized are imbedded in a resistor of finely-pulverized carbon, in a vertical clay tube surrounded by ashes. The upper terminal is a plug, loosely resting on the resistor and sinking as the carbonized articles shrink.

No. 248,437, Oct. 18, 1881, Thomas A. Edison, of Menlo Park, N. J.

Resistance type, for carbonizing filaments. The resistor is a U shaped horizontal vessel, of carbon, nickel or platinum, with a removable cover for introduction of the filaments. The vessel is filled with or surrounded by a gaseous carbon compound, e. g. naphthalene vapor.

No. 282,964, Aug. 14, 1883, J. L. Delaplaine, Joseph G. Den-drickson, and Francis H. Clamer, of Philadelphia, Pa.

Charge-resistance type. The furnace is a rectangular fire-brick structure, which is filled with tin-scrap or galvanized iron. Electric terminals pass through the walls into contact with the scrap, which is heated by resistance to such temperature that the tin and lead, or zinc, melt and run to the bottom, where they are drawn off. Any tin which does not melt is oxidized.

No. 319,945, June 9, 1885, Eugene H. Cowles and Alfred H. Cowles, of Cleveland, Ohio.

Charge-resistance type. Resistor of pulverized electric-light carbon or crystalline silicon. Two forms are shown: One is a horizontal cylinder of "silica," imbedded in charcoal or mineral wool. Zinc ore to be smelted is mixed with the resistor. One end of the cylinder is closed by a carbon-plate terminal; the other end by a graphite crucible with a perforated bottom, serving as a terminal and condenser for zinc-fumes. The second furnace is a rectangular fire-brick chamber, covered with a fire-clay slab having venting-openings. The terminals are vertical carbon plates, near the ends of the vessel. The resistor is a core extending between the plates and surrounded by charcoal, silica, corundum or lime. The ore to be reduced, e. g., corundum, cryolite, clay, or compounds of silicon, boron, calcium, manganese or magnesium, are mixed with the resistor. The reduced metal may remain in the interstices of the core or melt and run to the bottom.

No. 335,059, Jan. 26, 1886, Eugene H. Cowles and Alfred H. Cowles, of Cleveland, Ohio.

Charge-resistance type. Rectangular chamber of fire-brick, covered with a clay slab. The walls are lined with finely-pulverized charcoal which has been soaked in water impregnated with lime, the resulting coating of calcium oxide rendering the charcoal more resistant to heat and the flow of electric current. Or the charcoal may be soaked in water containing gelatinous aluminum hydroxide.

No. 360,144, March 29, 1887, Eugene H. Cowles and Alfred H. Cowles, of Cleveland, Ohio.

Charge-resistance type. The terminals are vertical superposed carbon tubes, the charge being fed into the top of the upper tube and the product from the bottom of the lower tube. The tubes are surrounded by a filling of pulverized charcoal, or lime and carbon, retained by walls of fire-brick, silica or lime. The charge is fed by a vertically-reciprocating carbon bar, with lateral projections, or by a rotary screw, in the upper electrode. The rate of feed and thereby the resistance of the furnace is automatically regulated by an electrically-controlled motor.

No. 390,964, Oct. 9, 1888, Abraham T. Hay, of Burlington, Iowa.

Induction type. Surrounds a blast furnace with superposed coils of copper wire, insulated with Manila paper and sodium silicate. The air for the blast is heated by passing between the iron furnace-shell and the coils. Electric currents are passed

through the separate coils, whereby the charge of the furnace "forms a magnetic core" which "will have its polarity repeatedly changed owing to the fact that the sections are separate magnets." The inflowing air is also said to be magnetized.

No. 391,034, Oct. 16, 1888, Henry H. Eames, of Baltimore, Md.

Resistance type. Drives off the sulphur and phosphorus from iron ore by placing it in vertical externally-heated retorts and passing an electric current through it. The retorts are of brick or iron lined with fire-clay. The electrodes are segmental metallic plates extending down along opposite sides of each retort. The ore is said to be heated and electrolyzed, the elimination of the phosphorus and sulphur leaving spongy iron.

No. 428,378, May 20, 1890, Edward A. Colby, of New Haven, Conn.

Induction type. A charge of metal to be melted and refined, for example platinum in the form of scraps, is placed in a deep, annular groove, formed in a block of fire-clay or lime. This charge constitutes the primary coil. Around the block is the secondary winding, of wire insulated with asbestos and wound on a slate spool. A core of iron wires extends through the open center of the block and around the coils. The furnace has an external brass casing, supported on trunnions, and an air-tight cover with pipes for withdrawing air and introducing gases and an observation opening closed by glass. An ingot mold depends from the cover, in such position that the molten metal flows into it when the furnace is turned on its trunnions.

Nos. 428,379 and 428,552, May 20, 1890, Edward A. Colby, of New Haven, Conn.

Induction type. Similar to the preceding, except that the lower part of the groove which receives the metal is lined with a trough of platinum or nickel, into the bottom of which leads a pipe for supplying gases.

No. 436,519, Sept. 16, 1890, Mark W. Dewey, of Syracuse, N. Y.

Resistance type. The resistor is a body of powdered or granulated carbon, coal, metal, or metal mixed with carbon, fire-brick, sand or pumice stone. It is supported in an open box of fire-brick or asbestos, containing terminal-plates of metal or other material. The ends of the box may be widened, to increase the contact-surface of the resistor and terminals. The resistance may be locally increased by an intermediate block of fire-brick resting on the box and partially subdividing the resistor. The resistor may consist of oil or a metallic liquid. The furnace is especially intended for heating metallic bars and blanks to be welded or worked.

No. 482,586, Sept. 13, 1892, Thomas Parker, of Newbridge, England.

Arc or resistance. The furnace is a vertical rectangular shaft. Three pairs of opposed horizontal electrodes pass through the side walls, at the bottom. These electrodes may be blocks of carbon fixed in metal casings, or may be of metal, with internal water-passages. The electrodes are automatically adjusted to maintain a uniform current, notwithstanding the varying resistance of the charge, by electrically varying the applied electromotive force. With alternating-current machines, the magnets of the exciter are controlled; with constant-current machines, the main magnets. Beneath the electrodes are starting-pencils of metal or carbon, which are initially pushed together to strike arcs or to bring the lower part of the charge to incandescence. The charge contains coke, which, coming in contact with the electrodes, maintains incandescence. Finely-divided carbon is supplied through side openings to the exposed ends of the electrodes, to maintain them in working order.

No. 494,585, April 4, 1893, Willis Mitchell, of Malden, Mass.

Resistance type. The furnace is a crucible, consisting of two sections of plumbago or metal supported by a U-shaped strip of asbestos or fire-clay, cemented thereto. Terminal plates, carried by a handle, are clamped onto the carbon sections.

No. 494,586, April 4, 1893, Willis Mitchell, of Malden, Mass.

Resistance type. The furnace is a crucible, consisting of two end sections molded from a mixture of graphite 4 parts and fire-clay 1 part, and an intermediate section of fire-clay. Cop-

per terminal-plates are imbedded in the end sections. A resistance bed of pulverized graphite is placed in the crucible, surrounding the article to be heated, which may be a small stone crucible or a horizontal muffle. The small crucible may be carried by an integral with the intermediate section.

NEW BOOKS

INDUSTRIE DES METAUX SECONDAIRES ET DES TERRES RARES. By Paul Nicolardot. 448 pages, 37 illustrations. Bound in cloth. Price, 5 francs. (Retail price in New York, \$1.25.) Paris, France: Octave Doin.

THE METALLIC ALLOYS. By W. Theodore Brannit. (A practical guide for the manufacture of all kinds of alloys, amalgams and solders used by metal-workers; together with their chemical and physical properties and their application in the arts and the industries; with an appendix on the coloring of alloys and the recovery of waste metals.) Third edition, thoroughly revised and enlarged. 579 pages, illustrated by 45 engravings. Bound in cloth. Price, \$3 net. Philadelphia, Pa.: Henry Carey Baird & Co.

THE IMPORTANCE OF THE MINING INDUSTRY TO THE INDUSTRIAL AND COMMERCIAL LIFE OF A NATION. By Harry Ja. Cantwell. An address delivered before the American Congress at Joplin, Mo. 8 pages. Paper cover, gratis. St. Louis, Mo.

MINES AND MINERALS OF THE BRITISH EMPIRE. By Ralph S. G. Stokes. (Being a description of the historical, physical and industrial features of the principal centers of mineral production in the British dominions beyond the seas.) 423 pages, illustrated. Bound in cloth. Price, \$4.20 net. New York: Longmans, Green & Co.

The bulk of this volume is based upon observations made and data collected during a tour of the British Empire extending from Jan., 1906, to the beginning of 1908. On this journey, a course was pursued from South Africa through Ceylon, India, Burma, Malay Peninsula, Australia, New Zealand, and Canada, etc.

SYNTHETIC INORGANIC CHEMISTRY. By Arthur A. Blanchard, Ph.D. A laboratory course for first-year college students. First edition. 89 pages. Cloth binding. Price, \$1. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

LABORATORY OUTLINE FOR DETERMINATIONS IN QUANTITATIVE CHEMICAL ANALYSIS. By Albert F. Gilman. 88 pages. Bound in cloth. Price, 90 cents net. Easton, Pa.: Chemical Publishing Co.

LEATHER TRADES CHEMISTRY: A PRACTICAL MANUAL ON THE ANALYSIS OF MATERIALS AND FINISHED PRODUCTS. By S. R. Troinail. 300 pages. Bound in cloth. Price, \$4.50 net. Philadelphia: J. B. Lippincott & Co.

THE SUGAR REFINING INDUSTRY IN THE UNITED STATES: ITS DEVELOPMENT AND PRESENT CONDITION. By Paul L. Vogt. 135 pages. Bound in cloth. Price, \$1.50. Philadelphia: John C. Winston Co.

THE STRUCTURE OF THE COTTON FIBER IN ITS RELATION TO TECHNICAL APPLICATIONS. By F. H. Bowman. 490 pages, illustrated. Cloth binding. Price, \$2.75 net. New York: Macmillan Co.

THE PURCHASE OF COAL UNDER GOVERNMENT AND COMMERCIAL SPECIFICATIONS ON THE BASIS OF ITS HEATING VALUE; WITH ANALYSES OF COAL DELIVERED UNDER GOVERNMENT CONTRACTS. By D. T. Randall. 27 pages. Paper binding. Price, 15 cents.

POWER GAS PRODUCERS; THEIR DESIGN AND APPLICATION. By Philip W. Robson. 239 pages, 105 illustrations. Bound in cloth. Price, \$3 net. New York: Longmans, Green & Co.

HYDRAULICS. By F. C. Lea. 548 pages, illustrated by tables and diagrams. Bound in cloth. Price, \$5. New York: Longmans, Green & Co.

HYDRAULIC ENGINEERING. By Gardner D. Hiscox. (A practical treatise on the properties, power and resources of water

for all purposes, including the measurement of streams, the flow of water in pipes or conduits; the horse-power of falling water; turbine and impact water-wheels; wave motors; centrifugal, reciprocating and air-lift pumps, etc. 320 pages, illustrated.) Bound in cloth. Price, \$4. New York: Norman W. Henley Publishing Co.

MECHANICAL ENGINEERING FOR BEGINNERS. By R. S. McLaren. 294 pages, with numerous illustrations. Bound in cloth. Price, \$1.75 net. Philadelphia: J. B. Lippincott & Co.

MACHINE DESIGN, CONSTRUCTION AND DRAWING. By H. J. Spooner. A text-book for the use of young engineers. 711 pages, with 86 tables and over 1400 figures. Bound in cloth. Price, \$3.50. New York: Longmans, Green & Co.

PROFIT-MAKING IN SHOP AND FACTORY MANAGEMENT. By C. U. Carpenter. 146 pages. Bound in cloth. Price, \$2. New York: Engineering Magazine.

FIRST PRINCIPLES OF THEORETICAL MECHANICS. By L. G. French. 37 pages, illustrated. Paper cover. Price, 25 cents. New York: Industrial Press.

PRINCIPLES AND PRACTICE OF ARTIFICIAL ICE MAKING AND REFRIGERATION. By L. M. Schmidt. Comprising principles and general considerations; practice as shown by particular systems and apparatus; insulation of cold storage and ice houses, refrigerators, etc.; useful information and tables. Third edition, revised and enlarged. 437 pages, 205 engravings. Bound in cloth. Price, \$3. Philadelphia, Pa.: Philadelphia Book Co.

PRACTICAL PAPER MAKING: A manual for paper makers and owners and managers of paper mills, to which are appended useful tables, calculations, data, etc. By G. Clapperton. Second revised and enlarged edition. 236 pages, illustrated. Bound in cloth. Price, \$2.50. New York: D. Van Nostrand Co.

CELLULOSE: Its raw material, manufacture, properties and uses; a handbook for manufacturers of celluloid and celluloid articles, and all industries using celluloid; also for dentists and teeth specialists. By F. Böckmann. Translated from the third revised German edition by Charles Salter. 123 pages, illustrated. Bound in cloth. Price, \$2.50. New York: D. Van Nostrand Co.

DEVELOPMENT AND ELECTRICAL DISTRIBUTION OF WATER POWER. By Lamar Lyndon. 323 pages, illustrated. Bound in cloth. Price, \$3 net. New York: John Wiley & Sons.

NOTES ON THE CONSTRUCTION AND WORKING OF PUMPS. By E. C. R. Marks. Second enlarged edition. 267 pages, illustrated. Bound in cloth. Price, \$1.50. New York: D. Van Nostrand Co.

INTRODUCTORY COURSE OF CONTINUOUS-CURRENT ENGINEERING. By A. Hay. 337 pages, illustrated by diagrams. Bound in cloth. Price, \$2.50 net. New York: D. Van Nostrand Co.

PRACTICAL PHYSICS. By W. S. Franklin, C. M. Crawford and B. Macnutt. A laboratory manual for colleges and technical schools, with figures and diagrams. Vol. I, Precise Measurements; Measurements in Mechanics and Heat. 173 pages, illustrated. Bound in cloth. Price, \$1.25 net. Vol. II, Elementary and Advanced Measurements in Electricity and Magnetism. 160 pages, illustrated. Bound in cloth. Price, \$1.25 net. New York: Macmillan Co.

THE CONDITIONS AND TENDENCIES OF TECHNICAL EDUCATION IN GERMANY. By Arthur H. Chamberlain. 108 pages. Bound in cloth. Price, 50 cents. New York: C. W. Bardeen.

TECHNOLOGICAL DICTIONARY IN FRENCH, ENGLISH AND GERMAN. Edited by A. Tolhausen. New edition revised by L. Tolhausen in three volumes. Vol. I (French), 821 pages, suppl. 197 pages; Vol. II (English), 960 pages, suppl. 77 pages; Vol. III (German), 851 pages, suppl. 189 pages. Bound in cloth. Price, \$2.75 net. New York: Macmillan Co.

THE WESTMINSTER SERIES. Price of each volume, \$2. New York: D. Van Nostrand Co.

India Rubber and Its Manufacture. By H. L. Terry.

Electric Power and Traction. By F. H. Davies.
 Liquid and Gaseous Fuel. By Prof. V. B. Lewes.
 Coal. By James Tonge.
 Iron and Steel. By J. H. Stansbie.
 Town Gas for Lighting and Heating. By W. H. Y. Webber.

BOOK REVIEWS.

LEAD REFINING BY ELECTROLYSIS. By Anson Gardner Betts.
 8vo., illustrated by plates and figures, 403 pages. Price, \$4.
 New York: John Wiley & Sons.

As this is the first treatise on this subject in any language, we heartily congratulate its author on his achievement. Satisfactory above all things is the fact that the man who has created the industry of electrolytic lead refining, takes on himself to tell us all about it. He says, in truly fine vein, in the preface: "The contained information is the result of a number of years of study, experiment and practical work, and is published in the hope that it will save those who may be interested in lead refining practice or its improvement the repetition of experiments already performed and give them the benefit of the work already done by others and myself."

The eleven chapters deal, respectively, with the study of the suitable electrolytes, deposition of antimony from the solution, manufacture of the fluosilicic acid, choice of system, refinery construction, operation and costs, lead product, slime treatment, analytical methods and bibliography; three appendices describe the parent plant at Trail, the newer plant at Graselli, and the newer methods of slime treatment. The reviewer has arranged these chapters in a more logical order than they are presented in the book, where the slime treatment is described before anything else about the process. The reason for this inversion is not hard to see. Mr. Betts has had more trouble with the working up of the slimes than with anything else, and he puts it in the forefront as the chief thing in his book.

The work as a whole is a metallurgical classic as to its substance, but not as to the manner of its presentation. There is nothing to criticize as to what Mr. Betts gives us, but we could have wished that the arrangement of chapters had been more logical, the treatment of the several topics more systematic, and the English language used more carefully and discriminatingly. In other words, the book lacks somewhat in orderly arrangement and literary polish. Perhaps we should say that these are immaterial as long as the information is there—and the information is there—but the finishing touches spoken of as lacking would have made the book more perfect as a metallurgical classic.

We cannot help discoursing on the vast difference between a broad-minded scientist who writes a book like this and a narrow-minded, money-making technologist who never writes a line or says a word about his own work in metallurgy or chemistry, and whose whole aim in life seems to be to get rich by keeping as much information as possible away from his fellow chemists. Such there are, connected with powerful commercial organizations, the fruits of whose labors are entirely absorbed by and inuring to the benefit of their money-grasping employers. Science, their foster-mother, gives them everything, and they return not an iota. They are leeches on the body scientific who share her life blood and contribute not one mite of sustenance to her in return. May they see Mr. Betts' altruistic contribution to science and industry and be forthwith ashamed of themselves and go and do likewise as far as it is in their power to do.

ABSORPTION OF VAPORS AND GASES BY SOILS. By Harrison E. Patten and Francis E. Gallagher. (With a preface by Frank K. Cameron.) 50 pages, 90 illustrations. Washington: United States Department of Agriculture (Bureau of Soils, Bulletin 51).

The work described in this bulletin marks the conclusion of an interesting series of studies of absorption carried out by

the Bureau of Soils and relating to subjects of great scientific interest, and at the same time of practical applicability in agriculture.

"The relation between the absorption of water vapor, on the one hand, and the evaporation of water from soil has been carefully investigated, and the laws controlling it have been clearly brought out, and the influence of soluble materials contained in the soil as affecting these laws has been shown. The significance of cultural methods as affecting either the absorption of water vapor or its evaporation has been shown. And finally, the important practical fact has been established that the wilting point—or that water content of the soil at which plants can no longer thrive and which has been shown elsewhere to be a physical factor of the soil—marks a water content higher than that which the soil can attain by direct absorption from a humid atmosphere, even though this latter be maintained at the point of saturation.

"The laws governing the absorption of other gases or vapors appear in general to be very similar to those governing the absorption of water vapor, and it may now be safely claimed that the broad subject of absorption of vapors by soils has been brought to a satisfactory state as regards not only our theoretical knowledge of the principles involved and their importance to practical agriculture, but also as they bear upon the practical methods of control."

* * * * *

A TEXT-BOOK OF ORGANIC CHEMISTRY. By A. F. Holleman, Ph.D., professor in the University of Amsterdam. Translated from the third Dutch edition by A. Jamieson Walker, Ph.D., and Owen E. Mott, Ph.D., with the co-operation of the author. Second English edition, rewritten. 589 pages, 80 illustrations. Bound in cloth. Price, \$2.50. New York: John Wiley & Sons.

The first English edition, which had been prepared from the second Dutch edition and was reviewed on page 430 of our first volume, has met with a demand so great as to exceed anticipation. It has been necessary to print a short edition from the existing plates during the revision of the text for the present second edition.

This second edition has been entirely rewritten. While it is based on the third Dutch edition of Holleman's "Leerboek der Organische Chemie," the progress of the science has necessitated numerous and extensive alterations. The book is, therefore, fully up-to-date.

Without going into details, we may repeat what we said in our former review of the general character of the work. "The Holleman book is not a descriptive or encyclopædic handbook. It is a text-book, in which the theory is presented with just sufficient description of organic compounds, to illustrate the classification. From this point of view it is an excellent work and full of suggestion."

* * * * *

JOURNAL OF AMERICAN PEAT SOCIETY. Vol. I, No. 1, April, 1908.

Published quarterly by the American Peat Society. Subscription price, \$2 per volume of four numbers. Single numbers, 50 cents. St. Clair Building, Toledo, Ohio.

On the industrial importance of the peat problem and on the formation of the American Peat Society, we commented editorially in our October issue last year. The first number of the *Journal* of this new society has just been issued. It is an octavo pamphlet of 22 pages and contains the following articles: C. A. Davis on the peat industry and its possibilities in America; O. K. Zwingerherger, some suggestions on peat machines; H. M. Wilson on swamp lands and their reclamation; W. G. Milne on peat as a steam fuel, and Julius Bordollo on a peat celebration.

We sincerely hope that this new journal and the society which is the sponsor for it will meet with success in their endeavor to bring the problems of the utilization of peat deposits nearer to practical solution.

Electrochemical and Metallurgical Industry

VOL. VI.

NEW YORK, AUGUST, 1908.

No. 8.

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH. D.....*President*
E. F. ROEBER, PH. D.....*Editor and Secretary*
C. E. WHITTELEY.....*Treasurer*

*Yearly subscription price for United States, Mexico and
United States dependencies, \$2.00; for all other countries, \$2.50
(European exchange, 10 shillings, 10 marks, 12.50 francs).*

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Entered as Second-Class Matter, June, 1903, at the Post Office at New
York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, AUGUST, 1908.

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The Chemical Engineer.

In his recent address at the inaugural meeting of the American Institute of Chemical Engineers, Dr. C. F. McKenna referred to the words of President Roosevelt in appointing the Commission for the Conservation of our National Resources. Its object is to conserve the foundations of our prosperity; to use our resources, but to so use them as to conserve them; not to limit the wise and proper development and application of these resources, but to prevent destruction and reduce waste. Dr. McKenna remarked that these words "are almost a good definition of chemical engineering." There is more truth in this claim than is generally understood. The point is that the chemical engineer should not be confounded with the industrial chemist. The latter's work is restricted to the chemical industries, the former's field of activity is much wider. Chemistry is at the bottom of our whole civilization and the chemical engineer should be called in far more often than heretofore in important undertakings. We hope the foundation of the American Institute of Chemical Engineers will have this result. But we know various instances where dire necessity works at present to the same end. Our manufacturers are now paying the engineering penalties of the past boom times. They are realizing the errors which were made when working under maximum pressure. But with true American spirit and energy they are overhauling their works, their methods of operation and their engineering staff. It is a characteristic sign of the times that in this period the chemical engineer is called in to contribute his share of knowledge and experience towards the end we all desire, the return of full-blast activity.

Hard Spots in Steel Castings and Diffusion in Fused Solutions.

This issue contains the conclusion of the article by Mr. Arthur P. Scott, chief chemist of the Dominion Iron & Steel Company, on the causes underlying the formation of a certain hard spot in a steel casting, with an application of the results of this experimental research to the general theory of diffusion in fused solutions. Our readers will certainly concur with us in the opinion that this is one of the prettiest and most interesting researches which have ever been published from the laboratory of a steel company. The investigation started with an analysis—macroscopic, microscopic and chemical—of the particular hard spot and its surroundings, and careful observation coupled with sound judgment led the author systematically to the synthesis of this particular kind of hard spots and the establishment of the physicochemical conditions under which they will occur. The practical steel man is, of course, primarily interested in the underlying cause—that a lump of ferromanganese failed of perfect admixture in the ladle—and it will be a matter of satisfaction to him that this can be generally

avoided by that degree of ordinary care which is always required in steel making. However, the chief interest of Mr. Scott's research lies in the establishment of the troubles which result from the diffusion phenomena occurring between a molten globule of ferromanganese and the surrounding steel. Since what happens is essentially a diffusion phenomenon, it is clear that the temperature will play an important rôle, and it is interesting to note the gradual variation of the phenomena with thermit steel, soft steel, rail steel, according to temperature.

* * *

A comparison between these phenomena in molten steel with the familiar phenomenon of a solution in water suggests itself immediately. Everybody knows the phenomenon of sugar dissolving in water, but it was not until Van't Hoff made his famous generalization on the parallelism between the laws for the pressure in gases and the osmotic pressure in solutions that laws for the latter were formulated. But Van't Hoff's theory only states the conditions which will be reached when equilibrium is established after complete solution. The mechanism of the solution while going on, is still unknown. It is the remarkable feature of Mr. Scott's experiments that he catches the diffusion phenomenon at several stages in its actual progress; the system while in diffusion being suddenly frozen so as to make it available to metallographic and chemical analysis. One result common to all his experiments stands out strongly. Whether diffusion between ferromanganese and steel or between pig iron and steel were studied, there remains always a sharp dividing line between the two during progress of diffusion; each portion of the two essentially maintains its individuality until diffusion is completed. This fact does not fit well with our familiar conception of solution of sugar in water, though we know little about the facts in the latter case. But it fits exceedingly well, as shown by Mr. Scott, with the well-known phenomena of diffusion between pure water and a sugar solution, when separated by a semipermeable diaphragm. This parallelism goes further. The bounding surface between the steel and the ferromanganese acts really like a semipermeable diaphragm, permeable for iron, but not for manganese, etc. This fact is so interesting that it should attract the attention of scientific investigators. In the study of fused solutions, experimental methods of research are available which we cannot employ in aqueous solutions. (To avoid a misunderstanding, we may modify here in parentheses our former remark that a sharp dividing line between the two systems in course of diffusion is an unfamiliar conception with aqueous solutions. As a matter of fact, for the diffusion of water and an electrolytic salt solution, Nernst's osmotic theory leads immediately to the same result, since it postulates that on account of the difference of mobility of the different ions an electric double layer (Helmholtz' doppelschicht) will be established. But Nernst's theory evidently does not apply to Mr. Scott's solid solutions.)

* * *

One particular point in Mr. Scott's paper deserves further attention and investigation. He makes it plausible and probable that a part of the gases that are commonly in solution or combination in molten steel, does migrate with the iron into the manganiferous body. The latter has a lower solvent power for the gases, and when they arrive they are thrown out of solution. The manganiferous iron body increases in size. We have

now a double tendency for further expansion; first the affinity which drives the iron from the outside into the manganiferous body, and second the pressure of the gases inside. The phenomenon becomes now quite complicated, but all experimental results of Mr. Scott are thereby easily explained. While this research has led to a complete answer of all questions as to the particular hard spot under test, we trust it will open up a new era of research on fused solutions.

Iron and Steel Statistics.

The Annual Statistical Report of the American Iron and Steel Association for 1907, which has just made its appearance, contains the usual fund of accurate and complete statistics, clearly presented, of the iron and steel industry of the United States. Some of the statistical information contained was given to the public early in the year, while some is entirely new. The production of pig iron has been doubling at an average rate of once in nine years, over a period of several decades, which means an average increase of about 8 per cent. each year. The increase has not been uniform. The alternate doublings require a longer period. Of late the rate of increase has been much more than 8 per cent. a year. Ten months of the year 1907 belonged to a period of rapid increase, and October showed the greatest month's production of all, while in November and December there was a rapid decrease. This made it that the year, which progressed so favorably, ended with but a slight gain in pig iron output over 1906, the increase being only from 25,307,191 gross tons to 25,781,361 gross tons.

* * *

So suddenly had the industry to slow down, towards the close of last year, that the retardation was not equal in all branches. While the production of pig iron showed an increase of 475,000 tons, the production of steel ingots and castings showed a decrease of 35,000 tons, to 23,362,594 tons. On the other hand, the total production of all rolled steel products showed an increase of 263,000 tons, to 17,664,736 tons. It may be noticed that there is a wide discrepancy between the production of steel, as reported, and the production of rolled steel. The production of steel ingots (excluding castings) was 22,559,477 tons, or 4,900,000 tons in excess of the production of rolled steel. The statistics are comparable, since practically none of the steel ingot tonnage was produced for any other purpose than rolling. Rolled billets which are used for forging are included in the statistics of rolled steel. The loss of nearly 5,000,000 tons was made chiefly in scrap, and this scrap, of course, was not wasted, but was used again, going chiefly to the open-hearth furnace. It is somewhat curious that the proportion should be so large, especially when there is complaint that some of the rolled steel produced is not sound, but should have been cropped more liberally. Doubtless there is more liberal cropping in plants where there is open-hearth practice calling for scrap, but this is not always the case. There are detached Bessemer plants, and there are open-hearth plants using processes which leave a portion of the refined steel in the furnace, to perform substantially the same mechanical function as is performed in ordinary practice when cold scrap is melted, to dilute the pig iron charged. One plant so operated customarily sells all its scrap made from low phosphorus steel, being able to obtain a fancy price from the steel casting

concerns, when with the ordinary open-hearth process it might be inclined to use the material in its own furnaces. Evidently there is a large loss in the handling, partial rolling and remelting of this steel which could be reduced by improved practice. Incidentally, the statistics of steel ingot production mean nothing; they are merely the records of the ingot scales, as has been remarked before. The industry cannot take the 19,000,000 tons of Bessemer and basic pig iron and manganese metals which were used and make 800,000 tons of castings and 23,360,000 tons of ingots, afterward getting only 17,665,000 tons of rolled steel from the ingots.

* * *

An interesting feature of the last four statistical reports has been the tonnage of rolled iron. With 1890 the gathering of separate statistics of rolled iron was discontinued, the statistics including rolled iron with rolled steel. In some years the production of rolled iron probably dropped below 1,000,000 tons, having been 2,518,194 tons in 1890. Of late there has been a revival in rolled iron, due to the great increase in the outcome of scrap, which left material for the rolling mill, despite the keen demand of the ordinary basic open-hearth steel practice. For 1904 the production of rolled iron was given at 1,760,084 tons, while in 1907 this increased to 2,200,086 tons. This was a slightly larger tonnage of rolled iron than was made in 1888, but in that year the production of rolled steel was not much greater than that of rolled iron. The method of production, however, is altogether different. The early rolled iron was puddled iron; the present rolled iron is made largely from scrap, and what boiling is done is largely of cast iron, including turnings and other light material. The contest for the scrap outcome between the iron mill and the basic open-hearth furnace is largely one of cost, and as to cost wages cut an important figure in the iron mills. The wage scales were reduced for the year beginning July 1 by an average of about 8 per cent, and this is helping to keep the trade for the iron mill, with the slightly lower prices prevailing for finished product.

Worlds in the Making.

Prof. Arrhenius in his most stimulating book, "Worlds in the Making," elucidates several principles more or less original to him. The first of these in novelty is, in our opinion, the possibility of life-spores or germs being carried to the upper atmosphere by air currents, the results of large meteoric disturbances, and there being electrified by the electromagnetic radiations from the sun with a charge opposite to the earth's charge. Hence, they are slowly repelled further by what the author terms "radiation-pressure" or a continuous process of slight additional electrifications. So they drift into cosmic space, dormant, because of the cold, but yet not dead—to find in the course of countless ages, on the theory of probability, some other planet suitable for organic growth. Of course, it is well known that the extreme evolutionists, like Prof. Haeckel, of Jena, had said that: first, no life could have existed at one time on earth when a molten mass (which fact every scientific mind must allow), and that, second, no germ cell could come into the world because of the heat engendered when the cell struck the atmosphere—as Prof. W. K. Clifford put it, "no simple proto-plasmic shape could come down a fire escape." Finally they deduced that life must have originated from the evolution

of the inorganic molecules to complex organic molecules. This while not impossible would appear to us to require countless aeons and not to have been at all probable. Thus far experiment negatives the possibility. Prof. Svante Arrhenius at present studying the infinite of astronomy, geology and cosmical physics, as he at one time studied so well the infinitesimal of molecular physics, expositis lucidly the broad facts and theories of earthquakes, the formation of solar systems, the modern nebular hypothesis and other things too diverse to mention. But his explanation of the cosmic transmission of germ cells is to us a most pleasing and rational "deus ex machina" in solving not the origin of life in the universe, but the origin of life on this insignificant, tiny world of ours.

* * *

Another novel idea, never before published to our knowledge, though proposed by at least one man privately and independently, is more practical in its bearing on our industrial life. This is the influence of the increase in consumption of coal and the result of it on the percentage of carbon dioxide in the atmosphere. The further consequence of this will be to increase the rate of growth of vegetable life. The present proportion of carbon dioxide in the air is about 1 part in 2500. It can be estimated by extrapolation that at the present rate of growth of the consumption of coal and all other combustibles the total increment of carbon dioxide from this source will result in the doubling of this figure in the course of two or three centuries. Naturally, this is but a rough estimate, though it is substantially correct. The rate of growth of plant life will be consequently greatly increased. For experimental evidence in proof of the increase of this growth with increasing proportion of carbon dioxide is at hand from work done in the botanical laboratory.

* * *

A tree can be regarded as a nature-made photochemical absorption apparatus working on extremely dilute gases. Hence, the multitude of leaves so placed as to give an enormous surface to both light and air. And a doubling of the percentage of gas to be absorbed evidently should more than double the "reaction-velocity" of the absorption. We know, too, that the percentage was in the carboniferous and cretaceous age so great as to cause the surface of the earth to be covered with vegetation, beside which the luxuriance of our present tropical vegetation would resemble the colloquial thirty pieces of our minimum coinage. And the decline of the monstrous fauna of the Paleozoic eras—such as the megatherium—has been caused by the decline of the luxuriant flora on which they fed. This decline, in turn, was caused by the locking up of so much carbon in what are now coal fields and limestone beds.

* * *

Thus, Arrhenius has made the brilliant prediction that in the course of time the growth of timber will be so much faster than it is at present, that, with the aid of hydro-electric installations, the problem of heat and power and metallurgical demands, will be postponed to the distant future, because it is not "ashes to ashes, earth to earth," but carbon to carbon dioxide, carbon dioxide to carbon. Thus a cycle of regeneration is instituted or at least suggested. In consuming our coal we are changing it into a form in which trees can more easily recapture it, to be again serviceable to the human race. This is a comforting and optimistic thought.

The Iron and Steel Market.

July has shown a material and clearly marked improvement in nearly all branches of the steel trade. The buying has been better and production slightly larger, than in June. The showing has been very satisfactory to the steel trade, since July is usually the quietest month of the year, and for it to show an improvement over June is therefore very favorable. At the same time it is recognized that the buying in July has been of an intermittent character and it has been evident that buyers are merely supplying their requirements in a hand-to-mouth fashion. The reductions in prices early in June settled the market for a while, buyers hesitating, so that on account of this unsettlement and the desire to pass over the midsummer inventory period purchases were in considerable degree deferred. This, it is inferred, has tended to make the actual buying present a distorted view of the real demand, and the trade, while feeling very hopeful for the future, is not disposed to conclude hastily that the improvement in buying in July over June necessarily presages a continued movement towards greater and greater activity. It is believed in most quarters that there will be a gradual improvement through the half year, but not a great deal of faith is felt in the movement which has occurred thus far.

The tin plate industry has run at almost full capacity through July, which is quite contrary to precedent, and is due to the lateness of the beginning of the buying movement for the spring trade. Since the middle of February the tin mills have been making more than 90 per cent of their normal output in the period, if indeed they have not fully equalled it. The wire industry has been operating to 75 per cent, and still maintains about that gait. Sheets and merchant pipe have averaged about 50 per cent, and the improvement in July brings them back to about that rate. The plate, shape, rail and merchant bar mills have been doing materially less than 50 per cent and have shown no great improvement in July over the average of the first half.

A new penalty system has been adopted in the Lake Superior ore trade, on the insistence of furnace interests. Until this change, Lake Superior ores, except special grades such as silicious ores, have sold on the straight unit basis. The standard price is fixed for Bessemer and non-Bessemer, Mesaba and old range, and the ores are sold on a guarantee of 55 per cent iron for Bessemer ores and 51.50 per cent iron for non-Bessemer, both in the natural state. From this basis the unit price is ascertained, and hitherto the premiums and penalties have been on a straight unit basis. This, of course, is not altogether equitable, as prices are f. o. b. Lake Erie docks, and the consumer must pay freight to the furnace on the material which is not iron, having besides to suffer a decrease in output and an increased coke and limestone cost, if the ore runs below the guarantee.

The new system leaves the penalty on a straight unit basis down to 50 per cent iron. Between 49 and 50 per cent the additional penalty is increased by 50 per cent, and below 49 per cent it is increased by 100 per cent. Thus, on Bessemer ores, the guarantee being 55 per cent, five units are deducted if the ore runs 50 per cent. If, for instance, the ore runs 49.50 per cent, three-fourths of a unit additional is deducted, making the total penalty $5\frac{3}{4}$ units; if the ore runs 49 per cent, $6\frac{1}{2}$ units are deducted; if 48.50 per cent, $7\frac{1}{2}$ units are deducted; if 48 per cent, $8\frac{1}{2}$ units, and so on. The ore interests embraced the opportunity slightly to increase the premiums on ores running above the guarantee. For one additional unit above 55 per cent on Bessemer and 53 per cent on non-Bessemer ores the unit price is increased by one cent; for the next unit two cents, and so on up to five, beyond which the standard unit price prevails.

PIG IRON.

The pig iron markets have been extremely dull, but at the end of the month are beginning to show more signs of life.

Sales during July have been the smallest for a long time. Prices have sagged off slightly, possibly 25 cents as an average of all districts and grades. Southern iron is weak at \$12, Birmingham, for early delivery, some interests being ready on occasion to shade this price about 25 cents. The large interests which sold large blocks for forward delivery at special prices are inclined to hold the market. In the Pittsburgh district Bessemer is still quoted nominally at \$16, valley, or \$16.90, delivered Pittsburgh, but on small lots for quick shipment this price could be shaded a trifle. Early in the month a sale of 10,000 tons of chill cast Bessemer was made at \$16, valley, for August, September and October delivery, this being the principal transaction. Basic is 25 cents lower, at \$15 to \$15.25, valley. The largest transaction was 8000 tons of prompt, bought by a Pittsburgh middleman on behalf of the Pittsburgh Steel Company, Monessen. The iron netted the furnace \$15.25 at furnace, but the freight rate from this furnace to Monessen is 85 cents, against \$1.10 from the valleys, so that the sale was made on the basis of \$15, f. o. b. valley furnace. Foundry iron is quoted at \$14.75 to \$15, valley furnace, and forge at \$14.

STEEL.

The billet market has been very quiet, not enough business arising to test thoroughly the stability of the regular price of \$25, Pittsburgh, for 4 x 4 billets, ordinary carbons. Sheet bar shipments have kept up well, and there have been a number of small transactions, at the full price. Most consumers are covered by regular contracts. The market is firm, at \$27.50 delivered Pittsburgh and nearby points, and \$27, f. o. b. Pittsburgh for other points.

FINISHED PRODUCTS.

A slight improvement has been noted in railroad buying. No large orders are being placed, but small orders are coming from a larger number of railroads than formerly, and quick shipment is desired in all cases. The work being done by the railroads is nearly altogether in the line of locomotive, car and track repairs, very little new work being under way. Buying of sheets has improved slightly and the improvement gives some promise of permanence. Buying of wire products in July has been better, relative to second quarter business, than is usually the case, and the same is true of merchant pipe. The few mills making line pipe, about 12 in., are quite busy, chiefly on some large contracts placed by the Standard Oil Company, and this has given a good bit of work to some plate mills, Homestead in particular.

The wage scale for union rolling mills was arranged July 11 at Detroit between the Western Bar Iron Association and the Amalgamated Association, the scale being accepted afterwards by the Republic Iron & Steel Company and the independents not represented at Detroit. The reductions average about 8 per cent. The puddling scale provides a rate of \$5 a ton when iron bars at \$1.20 cents or less; for each twentieth cent above 1.20 cents the puddling rate advances $12\frac{1}{2}$ cents. The old scale started with \$5 puddling on one-cent bar iron, advancing $12\frac{1}{2}$ cents for each twentieth cent advance in the bar iron price, so that on the higher number the new puddling rate is 50 cents lower than the old. The bi-monthly settlement showed an average realized price on bar iron shipped during May and June of between 1.35 and 1.40 cents, making the puddling rate \$5.37½. The previous rate had been \$6.12½, based on a 1.45-cent bar iron price, and the old wage scale.

Official prices, which are strictly held, except for occasional shading in sheets and narrow plates, and regular shading of \$3 to \$5 a ton in light rails, are as follows, all f. o. b. Pittsburgh, except that standard rails are f. o. b. northern mill:

Standard rails, 50 lb. and heavier, \$28.

Light rails, 25 to 45 lb., \$28.

Plates, 1.60 cents for tank quality.

Shapes, 1.60 cents for beams and channels, 15-in. and under, angles and tees; 1.65 cents: large beams, 1.70 cents.

Steel bars, 1.40 cents, base. Iron bars, 1.40 cents, delivered Pittsburgh; 1.35 cents, f. o. b. Pittsburg for western shipment, and 1.50 cents, Chicago.

Sheets, 2.45 cents net, for black and 3.50 cents net, for galvanized, 28 gage.

Tin plates, \$3.70 for 100-lb. cokes.

Wire nails, \$1.95; plain wire, 1.70 cents.

New Haven Meeting American Chemical Society.

The thirty-eighth general meeting of the American Chemical Society was held in New Haven, Conn., June 29th to July 2d, and was one of the most successful summer meetings ever held by the Society. Two hundred and fifty members were present and one hundred and seventy-four papers were presented.

The large number of papers made it necessary to hold more sectional meetings than usual, and the Society met in six sections for the presentation of papers.

The Society met in the lecture rooms of the Sheffield Scientific School, and the following nine papers were presented in general session before all the members: "Official Inspection of Commodities," by A. L. Winton, chairman of the agricultural and food section. "The Increasing Importance of the Rarer Elements," by P. E. Browning, chairman of the inorganic section. "The Analyst, the Chemist and the Chemical Engineer," by Wm. D. Richardson, chairman of the industrial section. "A Discussion of Some of the Methods Used in Determining the Structure of Organic Compounds," by Wm. McPherson, chairman of the organic section. "Our Present Knowledge of Plant Proteins," by T. B. Osborne, chairman of the Biological and sanitary chemistry section. "Some Applications of Physical Chemistry," by Frank K. Cameron, chairman of the physical chemistry section. "Chemical Publications in America in Relation to Chemical Industry," by W. A. Noyes. "The Electrolytic Theory of the Corrosion of Iron as Applied to the Protection of Steam Boilers," by W. H. Walker. "The Research Chemist," by W. R. Whitney.

On Wednesday afternoon, July 1st, an excursion to Ansonia was enjoyed by the visiting chemists for the purpose of visiting the works of the Ansonia Brass and Copper Company and the Coe Brass Manufacturing Company. On the evening of the same day the members met on the east shore for a social outing and dinner.

The organization of the Division of Industrial Chemists and Chemical Engineers was a feature of the meeting, and the following officers were elected: Chairman, A. D. Little; vice-chairman, A. H. Low; secretary, B. T. B. Hyde; executive committee, Wm. H. Walker, Wm. Brady, J. D. Pennock, W. C. Ebaugh, F. B. Carpenter. Twenty-eight important papers were presented before the Division and marked enthusiasm was shown. A movement is also on foot for organizing the Food Chemists, the General and Physical Chemists and the Fertilizer Chemists.

The rapid growth of the Society under the impetus of the organization of chemists into special groups and the continually improving quality of its journals was noted by all, seven hundred new members having been added in the last eight months.

Matters of decided importance were brought before the council and acted upon. A new section of the society was established with headquarters at Louisville, Ky. It was decided that the winter meeting should be held in Baltimore in affiliation with the American Association for the Advancement of Science, and that the summer meeting for 1909 should be held in San Francisco.

The society having been represented by its president in the recent conference in Washington on the conservation of our natural resources, it was voted that a standing committee on the conservation of our natural resources be established, and that the American Chemical Society should attempt to point

out how chemists can assist this movement which, it is believed, will lead to important results.

W. D. Richardson was elected editor-in-chief of the new *Journal of Industrial and Engineering Chemistry*, and thirty-four gentlemen were elected as associate editors to cover the different branches of chemical and metallurgical industries.

The committee on the qualifications of chemists made a preliminary report on the establishment of an institute of chemistry, which has been under consideration for the past two years.

It was decided, however, on account of its great and far-reaching importance, to refer this matter again to a representative committee of fifteen for further consideration to report back to the council.

The committee appointed to consider the training and education of chemists and chemical engineers made its report, and as a result a movement is under way to establish a section or division of chemical education within the society, which shall especially appeal to teachers, and shall study more particularly the existing standards and methods of instruction throughout the country, and the possibility of improving same.

The society adjourned after one of the pleasantest meetings in its history.

CORRESPONDENCE.

Steel Foundry Practice.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—In your June issue, Mr. R. H. Wolff, U. S. Representative for the Héroult electric furnace, publishes a transcript of analyses of steel made by that process, evidently covering an entire month's output, and makes some statements in conjunction therewith, all of which are most interesting to the modern steel-maker.

The record of the La Paz analyses commands attention for its very low average of sulphur and phosphorus, particularly the former. But while it is generally conceded that steel containing what may be called a minimum of these objectionable elements can be produced in the electric furnace, and that great progress has been made by very eminent men in developing that process, I submit that the major portion of Mr. Wolff's remarks on steel founding are of interest chiefly because of their unfairness to a large quota of ingenuous and intelligent men, whose efforts toward improving steel foundry practice have been crowned with very gratifying results, and who are still finding time, in the routine of their regular shop duties, by experimentation and observation, to evolve methods promising better things for the future.

Mr. R. A. Hadfield has said, "There is no rapid or royal road to the production of sound steel castings: this is only attained by long experience combined with specialized knowledge." Every steel founder knows this to be true, but his patience and untiring zeal have brought his adopted industry to a higher degree of excellence during the past five years than he formerly imagined possible. In this he has been wonderfully assisted by the producers of various refining and other alloys, to whom he is glad to render due credit.

Many instances could be cited in proof of improvement in steel foundry practice, in recent years, as for example, the use of aluminium, in quieting the steel, since the advent of ferro-manganese and ferro-silicon. One steel foundry of which the writer has knowledge, ten years ago added 8 lb. of aluminium to a 10-ton basic open-hearth heat. Six years ago it was customary in another steel foundry to use 10 lb. of aluminium in a 25,000-lb. basic heat. At the present time, 4 lb. of aluminium (without any of its alloys) is quite sufficient for a 22-ton heat, made on a basic hearth, for castings requiring a homogeneous machined surface.

As to examples of shapes formerly unheard of in steel molding, in the last two years, castings of $\frac{5}{8}$ in. sections in all parts,

with over-all dimensions of 13 ft. 10 in. x 9 ft. 9½ in. x 1 ft. 4¼ in., weighing but 3750 lb. have been successfully made in basic open-hearth steel, and at present complete underframes for locomotive tenders are being cast by the same process, 22 ft. 5¼ in. long, 10 ft. 2 in. wide, and 2 ft. 1 in. deep, weighing only

in and month out, will run under an average of 4 per cent of "scrap" castings, if it be not necessary to work a night shift of molders and core-makers, and 6½ per cent if operating under the latter handicaps. The yield of good castings will average 68 per cent of the metal charged into the furnaces in basic practice, and 70 per cent with acid bottoms, this difference resulting from the lower melting loss of the latter. As to causes for bad castings, steel foundries entirely agree with Mr. E. S. Cramp, who has stated that "one of the most fertile sources of defects in castings" (steel) "is a bad design"—and progressive steel foundries, of whom there are many, are learning rapidly how to solve the problems of such designs, when the engineers are prohibited from improving them, from a foundry standpoint.

I trust, while Mr. Wolff's criticisms are fresh in mind, that you will afford space in your journal for the publication of this letter, together with appended chart, showing what was in 1900 regarded as excellent practice in what was then considered the best and most modern type of basic furnace, under the skillful manipulation of a melter of technical and practical ability, and what is now being done. For purposes of thorough comparison, I have also charted the phosphorus and sulphur determinations from the La Praz laboratory record. Note, however, that I have not shown the carbon in the latter, having no knowledge that a uniformity of this element was aimed at in the electric furnace, as was in the case of the two open-hearth basic furnaces. I hope you will also reproduce enclosed photograph showing examples of physical qualities of steel made in the daily routine, without the melter's knowledge that the tests were to be made.

The writer by no means poses as being associated with a select organization of steel foundries who are responsible for most of the improvement made in recent years, for he knows that many of his colleagues can produce as conclusive evidence as he of the advanced and still advancing stage of the art. Your journal is of such value to metallurgists generally, and is consequently read by so many intelligent engineers, that Mr. Wolff's article is liable to do great harm to an industry that deserves better treatment, unless replied to by one who knows.

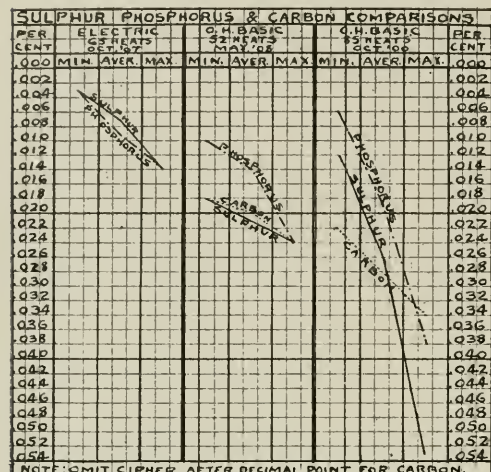


FIG. 1.—SULPHUR, PHOSPHORUS AND CARBON COMPARISONS.

9930 lb. The Tropenas converter has enabled the steel founder to make steel castings of comparatively infinitesimal dimensions and wafer-like sections. I recall a certain lot of 300 of such castings, weighing 14 to the pound, that were successfully turned out. Because of the established fact that the last part of a basic heat is not suitable metal for castings to be subjected to severe strains (the analysis suddenly changing as the slag line nears the nozzle), several foundries are now pouring that portion of the heat in ingots or in pigs on the floor, to be remelted and refined. This speaks for itself, not only of the progressiveness, but the conscientiousness of the modern steel casting producer.

So much for Mr. Wolff's statement that "it is a well-known fact that the steel casting industry has made no progress of late years." But Mr. Wolff further states, "I am told, on good authority, that there is a wastage of about 50 per cent in medium and light weight castings, particularly in castings of odd shapes. This is principally due to impurities and sluggishness of the metal in casting." It is difficult to decide whether by "wastage" Mr. Wolff means to include defective castings, sculls, gates, risers, chippings, melting loss, and any extra metal that may be added to sections to assist in running the metal, or whether the first mentioned, commonly called "scrap" castings are meant. In either case, however, the statement is wrong, and it is to be regretted if any practical steel founder has so misguided Mr. Wolff. A well-managed steel foundry, month

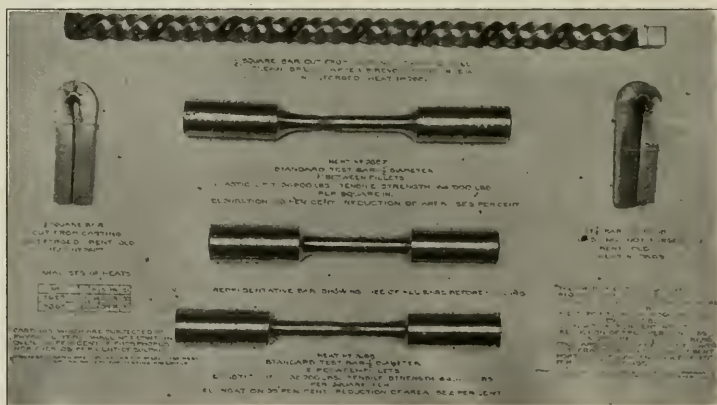


FIG. 2.—EXAMPLES OF PHYSICAL QUALITIES OF OPEN-HEARTH STEEL.

This is my apology for writing at this length on this incidental feature of Mr. Wolff's dissertation, which, in so far as it exhibits the refining possibilities of the electric furnace, excites my admiration.

R. A. BULL,

General Superintendent, Commonwealth Steel Company.
GRANITE CITY, ILL.

Treatment of Iron and Steel in the Electric Furnace.

By ERNESTO STASSANO, Major of Artillery, K. C. I. K. M. L.

In reading the November issue, 1907 (vol. V, No. 11), of *ELECTROCHEMICAL AND METALLURGICAL INDUSTRY*, my attention was attracted to the articles on the reduction of iron ore in the electric furnace (page 445) and on the Lash steel process (page 455). Both articles refer to iron reduction in the electric furnace and point out the difficulties which interfere with the practical solution of the problem. But these difficulties were solved by me years ago.

It may be of interest to give here the results which I have regularly obtained for some time, and which prove that the application of the electric furnace to the treatment of iron ores and of iron agglomerates in general has passed the scientific

stage, and that with energy produced by water power at a cost of lira 40 (\$7.72) per hp-year, or lira 0.005 (about 0.1 cent) per hp-hour, and with fuel costing lira 20 (\$3.86) per ton, the electric furnace is on equal terms with the blast furnace.

Second, to make the most of electrically generated heat for

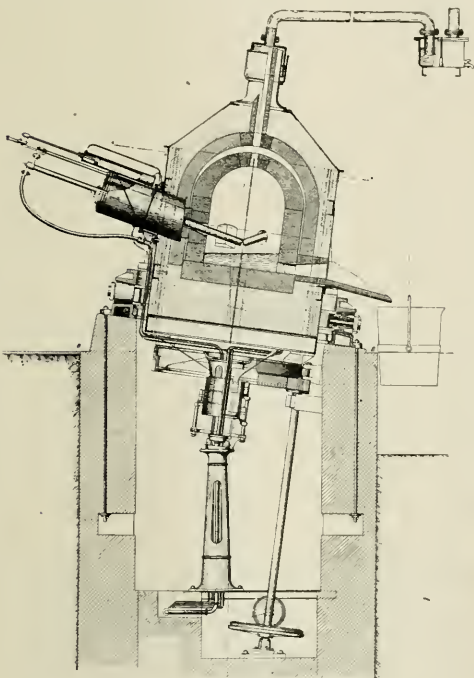


FIG. 1.—VERTICAL SECTION OF ROTARY ELECTRIC FURNACE.

experimental stage and has taken its place in the industrial arts.

After a long theoretical investigation of this problem, which is of utmost importance to countries poor in fuel, I made, in 1898, the first practical trial. This first attempt was satisfactory indeed, since in the first run I succeeded in turning out malleable iron directly from ore in a single operation.

As to the consumption of energy, I was led to entertain the hope that with more adequate apparatus the utmost economy might be obtained and that the inconveniences, which are always found in apparatus built for a first experiment, could be overcome with such ease as to approach almost the theoretical limit of efficiency.

In my memoir presented at the sixth International Congress of Applied Chemistry at Rome, 1906, I summed up the results of my studies made since 1889, and proved:

First, that a maximum consumption of 4 hp-hours is quite sufficient to produce in an electric furnace the same results as

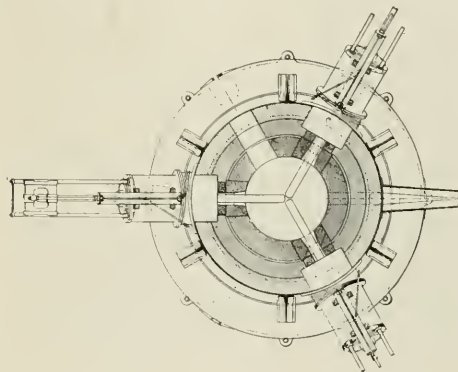


FIG. 2.—HORIZONTAL SECTION OF ROTARY ELECTRIC FURNACE.

industrial and particularly metallurgical purposes, the apparatus should fulfill the following fundamental conditions:

(a) The chamber in which the electrical energy is transformed into heat and in which the metallurgical process takes place should be protected from the atmospheric air, so as to provide an absolute neutral atmosphere.

(b) The heat should be generated from electricity at the highest possible temperature.

(c) The material to be treated ought not to come into contact with other substances which might have a pernicious influence upon the composition.

(d) The whole apparatus, wherein the various operations are executed to obtain a predetermined final product, should be designed and built so as to work continuously at full charge.

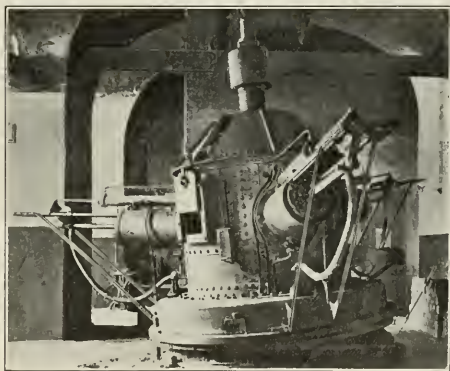


FIG. 3.—200-HP ROTARY ELECTRIC STEEL FURNACE, ARTILLERY WORKS, TURIN.

Without repeating the particulars published in the above paper, I will limit myself here to the description of the furnaces invented by myself in order to make the best use of this new heat producer for metallurgical purposes.

Figs. 1 and 2 show diagrammatically my rotary electrical furnace, consisting of an iron-sheet cylinder with conical roof

TABLE A.—DIRECT CONVERSION OF ORE INTO IRON AND STEEL IN A 200-H.P. FURNACE.

Composition of the charge.		ANALYSIS.		TESTS.	
		Charge %	Casting %	Breaking load kgs per sq. mm.	Elongation %
1000. Ore ¹	Fe ² O ³	68.700	Fe 99.485	...	...
350. Lime	Mn ² O ³	3.229	C 0.22	...	...
240. Charcoal	Si O ²	17.150	Mn 0.120	...	...
80. Aqueous solution of silicate of soda at 25%	Al ² O ³	2.	Si 0.070	...	...
	Ca O	1.	Ph 0.010	...	...
	Mg O	5.670	S 0.065	...	...
	Ph	0.150		...	...
50. Calcium Carbide	S	0.120		...	...
Identical charge ²	do		Fe 99.450	55	23
			C 0.260	...	...
			Mn 0.210	...	...
			Si 0.030	...	...
			Ph 0.010	...	...
			S 0.040	...	...
Identical charge ³	do		Fe 99.235	...	...
			C 0.500	...	...
			Mn 0.240	...	...
			Si 0.140	...	...
			Ph 0.015	...	...
			S 0.070	...	...
Identical charge with addition of hematite pig-iron for recarburization ⁴	do		Fe 98.620	80.3	13
			C 0.800	...	...
			Mn 0.300	...	...
			Si 0.220	...	...
			Ph 0.015	...	...
			S 0.045	...	...

¹ The energy consumption in this run was 4.5 kw.-hours per kg of casting.² Energy consumption 4.3 kw.-hours per kg. In these runs the calcium carbide was introduced after removal of the slag.³ Energy consumption 4.2 kw.-hours per kg. The hematite pig-iron was added after removal of the slag.

TABLE B.—FERRO-ALLOYS FROM ORE IN 100-H.P. FURNACE.

Composition of charge.		ANALYSIS.	
		Charge %	Casting %
1000. Wolframit ¹	W O ³	69.800	Fe 35.200
190. Charcoal	Si O ²	2.000	W 58.000
40. Lime	Fe O	20.500	C 2.400
80. Solution of 25% Silicate of Sodium	Mn O	7.300	Mn 3.192
	S	0.200	Si 1.244
	Ca O	traces	Ph traces
	Mg O	traces	S traces
	Ph ² O ³	do	Fe 28.630
Identical charge ²	do		W 65.660
			C 2.062
			Mn 3.500
			Si 1.028
			Ph traces
Identical charge ³	do		Fe 22.715
			W 69.700
			C 2.508
			Mn 3.600
			Si 1.300
			Ph traces
			S traces
1000. Manganese-Ore ¹	Mn ² O ³	45.650	Fe 17.762
300. Charcoal	Fe ² O ³	16.100	Si 17.600
60. Lime	Al ² O ³	3.050	Mn 62.000
	Si O ²	30.160	...
	Ba O	0.150	C 1.800
80. Solution of 25% Silicate of Sodium	Ca O	1.200	S traces
	Mg O	0.430	
	S	0.817	
	Ph ² O ³	0.340	Ph 0.028

¹ The energy consumption in this run was 6 kw. hours per kg produced.² Energy consumption 6.8 kw.-hours per kg.³ Energy consumption 7.5 kw.-hours per kg. Theoretically the ferroalloys produced in the first three runs should contain 20.6% Fe, 71.5 W, 7.1 Mn, 1. Si.⁴ Energy consumption 7.4 kw.-hours per kg. The intention was to produce a silico-manganese, containing about 60% Mn and 20% Si.

lined on the inside with refractory material. The melting chamber is also cylindrical, with a cupola of the same firebrick. Suitable openings are provided for the electrodes, which project towards the center of the furnace, their ends being at proper distance from each other for the formation of the arcs and at a convenient height above the bottom.

The electrodes are protected on the outside by water-cooled cast-iron cylinders, fitted to the mantle of the furnace. The movement of the electrodes is controlled by guide-rods outside

TABLE C.—REFINING STEEL FOR PROJECTILES IN 200 H.P. FURNACE AT ARTILLERY WORKS, TURIN.

Composition of charge.		ANALYSIS OF CASTINGS.					Weight of output	Breaking load kg per sq. mm.	Elongation %
		C	Mn	Si	Ph	S			
350. kg Scrap		0.420	1.231	0.180	0.03	0.03	650	67	19
200. Broken Projectiles		0.440	1.498	...	...	...	665	74	17
100. Scrap Lathes		0.425	1.340	...	...	...	642	71	20
2.5 Ferro Silicon		0.400	1.386	...	...	...	630	67	19
10.5 Ferro Manganese		0.465	1.224	0.200	0.035	0.04	665	72	17
0.2 Aluminum		0.495	1.404	...	...	...	662	78	15
6. Lime		0.490	1.340	...	...	...	656	78	16
1. Ore		0.430	1.260	0.150	0.025	0.035	656	69	18
		0.525	1.296	...	...	...	650	79	15
		0.460	1.476	...	...	...	640	76	16
		0.515	1.436	...	...	...	670	81	15
		0.505	1.540	...	...	...	656	83	14
		0.450	1.264	0.170	0.031	0.033	650	76	16
		0.415	1.440	...	...	...	650	71	18
		0.445	1.332	...	...	...	652	76	16
		0.400	1.444	...	...	...	652	69	18
		0.405	1.501	0.180	0.030	0.027	655	71	18
		0.465	1.303	...	...	...	650	73	17
							11,749		

The weight of the material charged in 18 runs was 18 x 663 = 11,934 kg and that of the steel obtained 11,749, the loss being about 1% per cent. The electric energy consumption was 1.25 kw.-hour per kg of steel.

of the furnace. To the end of the carbon electrodes a metallic rod is fitted, the end of which is connected to a flexible cable leading beneath the furnace to the slip-rings for current supply.

Above each of the water-cooled cylinders, which protect the outside of the electrodes, a small hydraulic pressure cylinder is provided, the piston rod of which is connected with the metallic rod of the electrodes and thus controls the movement of the electrodes and regulates the distance between their terminals within the furnace.

The lower part of the furnace, somewhat above the bottom, is surrounded by an L-shaped rail of cast iron running upon conical rolls. Below the rolls there is another cast-iron rail, resting on the inclined top of the pit-wall and thus forming the support of the furnace. The longitudinal axle of the furnace is, therefore, inclined by a certain angle against the vertical.

The furnace is revolved by means of a strong gearing at the bottom. Attached to the head wheel are properly insulated copper rings, which, by means of copper bars and the above-mentioned elastic cables, transmit the current to the electrodes. The current is supplied from the generator to a series of brushes disposed round the top of an iron support in the center of the pit and cables. These brushes and slip-rings maintain a continuous connection between generator and electrodes during the rotation or standstill of the furnace.

Besides the brushes there is a distribution valve mounted on the top of the stationary iron support, which distributes the water for the pressure regulators and the cooling cylinders protecting the electrodes. Thus, like the electrical contrivance, acts continuously.

The discharge is at the bottom of the melting chamber, while opposite to it another opening is left for charging. In the center of the brick cupola an exit is provided for the volatile products of the furnace reactions. Through this exit the gases escape into a metal tube shut by a sand valve and leading to a vessel filled with water, from which the gases may escape into the open air or be used otherwise. This arrangement prevents any entering of air from the atmosphere into the melting chamber; neither could air get in on opening the charge hole or discharge hole since the pressure inside is higher than outside, on account of the higher tension of the gases at the elevated temperature inside.

It is obvious that this furnace does fulfill the conditions laid down before:

(a) From the chemical standpoint, the atmosphere throughout the melting chamber is neutral.

(b) The electric energy is transformed into heat by the voltaic arc at the highest temperature obtainable.

(c) The material treated is not in contact with the electrodes or other materials and hence its composition is not subjected to any alteration.

(d) The rotation of the furnace maintains the molten material in an active motion, facilitates the chemical reactions, already well prepared by the elevated temperature, shortens the

slag of the most suitable composition to absorb the impurities in one single operation.

Such a charge will be gradually heated with the exclusion of air. The flux cannot absorb oxygen from the air and maintains its quality also at an elevated temperature, so that it is able to fulfill its mission when the right temperature has been reached. Among the different oxides contained in commercial

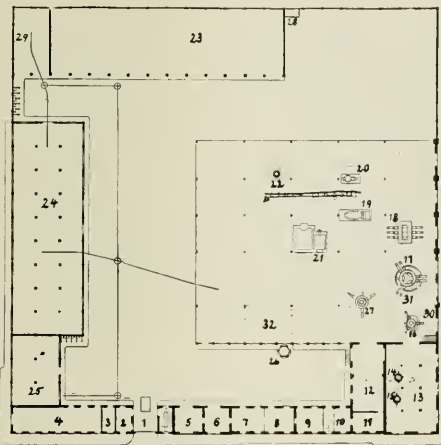


FIG. 4.—PLAN OF STASSANO STEEL WORKS, TURIN.

time of operation to a minimum, so that the furnace may always be used under full charge and the electrical energy utilized to the fullest extent.

On the other hand, this electrical furnace will not overheat the charge in a detrimental way. Indeed, if we express in a few words the chief characteristic features of this furnace, it is an airtight chamber with a thermic source in its center radiating heat at a very high temperature. Evidently the temperature of the chamber will increase and tend to reach gradually that of the voltaic arc, but will not reach it. Experience shows that if the right proportion is used between the charge capacity of the melt-

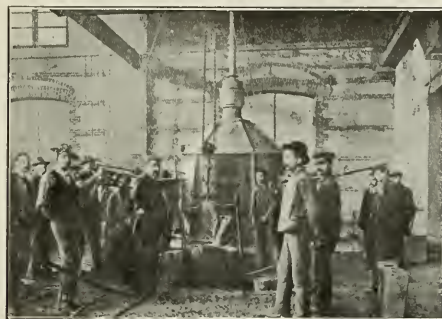


FIG. 6.—ROTARY 200-HP FURNACE OF STASSANO STEEL WORKS.

iron ore that of iron is the first one which is reduced. The remaining oxides (SO_2 , MnO , MnO_2 , CO , MgO , etc.) are, therefore, left without reducing elements and, hence, forced to pass, with the assistance of the flux, into the slag.

In the same way, if pig iron or iron scrap is used, mixed with slag-forming materials, the pig iron and impure iron may be successfully refined in the same furnace, and this is accomplished by starting from predetermined quantities without any necessity of control or tests during the process. The furnace furnishes only the heat to produce the reaction between the different substances of the charge; it does not introduce any other elements.

The reducing element which is used for absorbing the oxygen of the iron oxide is the carbon of common coal or of charcoal, which is the purest of all fossil fuels. When refining pig iron or impure iron, oxide of iron must be added,



FIG. 5.—100-HP STATIONARY ELECTRIC STEEL FURNACE, STASSANO STEEL WORKS, TURIN.

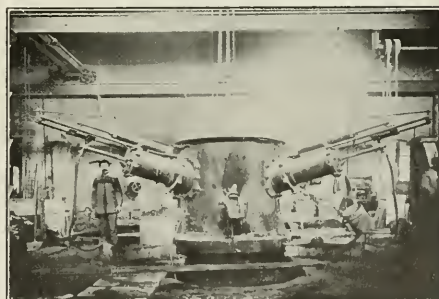


FIG. 7.—TILTING 200-HP FURNACE AT STASSANO STEEL WORKS.

ing chamber and the quantity of heat produced, the operation proceeds satisfactorily without overheating the charge.

From these premises it seems quite clear that refined iron may be obtained *from ore directly* in this furnace if it is charged with iron ore mixed in the right proportion with a reducing agent and fluxes able to transform the gangue into

which may be natural or artificial (hammerslag) or powder of rusty scrap. To make the slag, the common fluxes, used in metallurgy, are suitable and may be selected according to convenience and special requirements.

The furnace permits as well the extraction of iron directly from ore as the refining of pig iron and raw iron. Since the design and operation of the furnace exposes the material to the

TABLE D.—MILD STEEL CASTINGS MADE IN REVOLVING AND TILTING 200-H.P. FURNACES IN STASSANO STEEL WORKS, TURIN.

Composition of charge.	ANALYSIS OF CHARGE AND CASTING.					Breaking load kg per sq. mm.	Elongation %
	C %	Si %	S %	Ph %	Mn %		
330 kg Broken iron (picks etc.)	0.245	0.046	0.085	0.034	0.757	...	...
330. Lathe scrap, iron and steel	0.350	0.140	0.050	0.110	0.810	...	...
70. do., rusted	0.300	0.105	0.080	0.056	0.070	...	...
18. Hematite pig iron.	3.800	1.800	0.010	0.015	0.350	...	...
2.2 Ferro-silicon.	0.350	51.650	...	0.130	0.360	40.00	...
6. Ferro-Manganese.	6.409	0.233	...	0.295	70.732	19.00	...
30. Lime.	...	...	...	...	...	...	...
4. Calcium carbide	...	...	...	...	...	...	...
Output	0.200	0.330	0.050	0.038	1.020	...	...
Same charge—Output ¹	0.220	0.100	0.045	0.030	0.420	42	19
Same charge—Output ²	0.220	0.170	0.052	0.026	0.500	...	...
Same charge—Output ³	0.260	0.090	0.048	0.025	0.490	45	17.5
Same charge—Output ⁴	0.260	0.280	0.040	0.035	0.440	...	...
Same charge—Output ⁵	0.250	0.200	0.050	0.035	0.410	...	...
250. Foundry steel scrap.	0.230	0.150	0.042	0.030	0.450	...	...
350. Picks broken	like	above	...	...	...	...	...
150. Lathe scrap.	...	...	...	...	...	...	...
70. do., very rusty.	...	...	...	...	...	...	...
28. Hematite pig iron.	...	...	...	...	...	...	...
3.43 Ferro-silicon.	...	...	...	...	...	...	...
3.2 Ferro-Manganese.	...	...	...	...	...	...	...
30. Lime.	...	...	...	...	...	...	...
4. Calcium carbide	...	...	...	...	...	...	...
Output	0.270	0.130	0.040	0.025	0.399	43	20
Same charge—Output ¹	0.230	0.280	0.050	0.025	0.460	40	18.5
Same charge—Output ²	0.140	0.490	0.045	0.029	0.420	...	...
Same charge—Output ³	0.220	0.160	0.040	0.031	0.410	...	...
Same charge—Output ⁴	0.240	0.130	0.040	0.026	0.460	42	17
Same charge—Output ⁵	0.220	0.170	0.043	0.030	0.390	39.8	20.5
Same charge—Output ⁶	0.180	0.110	0.051	0.030	0.440	...	...
Same charge—Output ⁷	0.200	0.100	0.040	0.025	0.390	...	...
Foundry scrap	like	above	...	...	...	...	...
400. Scrap perfored sheets	0.300	0.130	0.070	0.290	0.210	...	...
150. Lathe scrap.	...	like	above	...	...	...	...
70. do., very oxidized	...	...	...	...	...	...	...
60. Hematite pig iron.	...	...	...	...	...	...	...
2. Ferro-silicon.	...	...	...	...	...	...	...
3.6 Ferro-Manganese.	...	...	...	...	...	...	...
35. Lime.	...	...	...	...	...	...	...
5. Carbide—Output ¹	0.300	0.250	0.058	0.035	0.490	45	19.4
Same charge—Output ²	0.300	0.090	0.055	0.040	0.360	...	...
Same charge—Output ³	0.280	0.080	0.045	0.035	0.610	...	...
Same charge—Output ⁴	...	like	above	...	...	...	...
200. Lathe scrap.	...	...	...	...	...	...	...
150. do., rusted.	...	...	...	...	...	...	...
45. Hematite pig iron.	...	...	...	...	...	...	...
1. Ferro-silicon.	...	...	...	...	...	...	...
4.3 Ferro-Manganese.	...	...	...	...	...	...	...
40. Lime.	...	...	...	...	...	...	...
5. Calcium carbide	...	...	...	...	...	...	...
Output	0.230	0.180	0.040	0.038	0.400	42	19
Same charge—Output ¹	0.230	0.200	0.045	0.038	0.520	...	...
Same charge—Output ²	0.220	0.090	0.050	0.035	0.400	...	...
Same charge—Output ³	0.230	0.210	0.050	0.035	0.660	45	14 ¹
Same charge—Output ⁴	...	...	...	...	...	...	...
Output	0.250	0.230	0.045	0.030	0.680	57	10 ²
Same charge—Output ¹	0.220	0.150	0.040	0.035	0.450	...	...
Same charge—Output ²	0.300	0.250	0.045	0.030	0.620	...	...
Same charge—Output ³	0.250	0.160	0.054	0.033	0.420	...	...
Same charge—Output ⁴	0.230	0.300	0.050	0.025	0.620	...	...

The product was used throughout for castings. The energy consumption was 1.260 kw. hours per kg. of output, this figure being the average for the year 1907.

¹ Ingots molten and annealed.

² Ingots forged and annealed.

most elevated temperature in a neutral atmosphere, it is easy to produce iron of the finest and purest quality. Everything depends on the temperature of the bath to render the reactions more active, the slag more liquid, by increasing the basicity and with it the clearing capacity. Since the atmosphere in the furnace is chemically neutral and the operation may be carried out at will for any length of time, the metal may be nearly entirely freed from all impurities without the risk of pernicious oxidation.

In the accompanying six tables, A to F, details are given of results obtained in actual practice, which, I hope, will prove the full agreement of practice with my theoretical studies. Indeed, all who have had an opportunity to acquaint themselves with my furnace in operation have become convinced of the soundness and success of the process. The tables A to F are almost self-explanatory and it may only be emphasized here again that they give the results of regular commercial operations at the Artillery Works of the Italian government in

TABLE E.—MANUFACTURE OF SPECIAL STEEL IN THE 200-H.P. REVOLVING AND TILTING FURNACES AT STASSANO STEEL WORKS.

Composition of charge	ANALYSIS OF CHARGE AND OUTPUT.					Breaking load kg per sq. mm.	Elongation %
	C %	Si %	S %	Ph %	Mn %		
400 kg Ondulated sheeting	0.300	0.130	0.070	0.290	0.210	...	...
200 Lathe scraps, very rusted	0.300	0.100	0.083	0.057	0.070	...	...
1.5 Ferro-silicon.	0.350	51.650	...	0.130	0.360	...	...
4. Ferro-Manganese	6.409	0.253	...	0.295	70.732	...	...
24. Nickel	...	...	...	...	...	Ni 99	...
20. Lime	...	...	...	...	...	Ni	...
5. Calcium carbide	...	...	...	...	...	...	...
Output	0.180	0.123	0.048	0.007	0.780	5.000	56 29
Same charge and 5 kg. carbide Output	0.165	0.110	0.015	0.007	0.690	5.56	54.5 30.1
70. kg White pig iron ¹	3.322	0.270	0.083	0.115	2.315	...	...
150. Lathe scrap rust ²	0.300	0.105	0.083	0.057	0.070	...	...
200. Lathe scrap steel.	0.350	0.140	0.030	0.110	0.810	...	...
236. Foundry scrap	0.230	0.130	0.030	0.037	0.450	...	...
45. Hematite pig iron	3.800	1.800	0.010	0.015	0.350	...	...
30. Lime.	...	...	...	...	...	...	...
12. Calcium carbide.	...	...	...	...	...	...	...
6. Ferro-Manganese	6.409	0.253	...	0.295	70.732	...	...
117. Tungstic acid	...	...	...	...	...	Cr	...
24.5 Charcoal	...	...	...	...	...	...	...
36.5 Chrome iron	5.800	1.300	0.070	0.028	0.450	70.000	...
1.5 Aluminium	...	...	...	...	...	W	...
Output	1.56	0.062	0.012	0.010	0.975	12.900	...
200. Hematite pig iron ²	3.800	1.800	0.010	0.015	0.350	Cr 3.500	...
16. Tungstic acid	...	...	...	...	...	...	...
600. Rotten picks.	0.245	0.046	0.085	0.034	0.757	...	...
2. Ferro-silicon.	0.350	51.650	...	0.130	0.360	...	...
3. Ferro-Manganese	6.409	0.253	...	0.295	70.732	...	...
Aluminium.	...	...	...	...	...	...	...
1. Calcium carbide.	...	...	...	...	...	...	...
25. Lime.	...	...	...	...	...	W	...
Output	0.960	0.123	0.018	0.018	0.600	1.560	...

All the output for ingots.

¹ This charge was made to produce rapid tool steel containing 1.500% C, 0.127 Si, traces of S and Ph, 1.000 Mn, 12.925 W and 3.690 Cr.

² This charge was made to produce steel containing 1.1% C, 0.28 Si, 0.07 S, 0.008 Ph, 0.4 Mn and 1.5 W.

TABLE F.—MANUFACTURE OF STEEL INGOTS FOR CASTINGS AND PROJECTILES IN THE 1000-H.P. FURNACES, ONE REVOLVING AND THE OTHER STATIONARY, IN STASSANO STEEL WORKS, TURIN.

Composition of charge.	ANALYSIS OF CHARGE AND OUTPUT.					Breaking load per kg sq. mm.	Elongation %
	C %	Si %	S %	Ph %	Mn %		
2600. kg Lathe scraps, steel	0.300	0.140	0.070	0.110	0.800	...	...
1400. Refuse of springs.	0.620	0.490	0.080	0.060	0.970	...	...
9.5 Ferro-silicon.	0.350	51.650	...	0.130	0.360	...	...
21.5 Ferro-Manganese	6.409	0.233	...	0.295	70.732	19.	...
4. Aluminium	...	...	...	...	...	Fe	...
30. Hammerslags oxide.	73.000	1.130	0.150	0.049	1.350	25.00	...
60. Lime.	...	...	...	...	...	O	...
15. Calcium carbide	...	...	...	...	...	...	...
Product	0.300	0.230	0.037	0.023	0.950	...	58 23
Identical charge	0.320	0.210	0.039	0.025	0.880	...	61. 19.8
Product	0.310	0.150	0.035	0.022	0.780	...	...
Identical charge	0.300	0.380	0.040	0.023	0.900	...	57. 21.5
2600. kg Lathe scrap steel ²	...	like	above	...	...	...	...
1400. Springs, scrap.	...	...	...	...	...	...	...
130. Hematite pig iron	3.800	1.800	0.010	0.015	0.350	...	...
4. Ferrosilicon	...	like	above	...	...	...	...
41. Ferromanganese.	...	...	...	...	...	...	...
4. Aluminium.	...	...	...	...	...	...	...
30. Hammerslags oxide.	...	like	above	...	...	...	...
60. Lime.	...	...	...	...	...	...	...
15. Calcium carbide	...	...	...	...	...	...	...
Product	0.450	0.085	0.038	0.030	1.215	...	69 18
Identical charge	0.420	0.046	0.040	0.027	1.150	...	...
Product	0.470	0.040	0.041	0.031	1.180	...	71 16.5
Identical charge	0.460	0.070	0.039	0.028	1.300	...	70 17

¹ This and the following charges were worked in the 1000-h.p. stationary furnace. The average energy consumption for the campaign was 0.958 kw.-hour per kg.

² This and the following charges were made in the 1000-h.p. revolving furnace, the product being ingots for projectiles. The average energy consumption was 0.918 kw.-hour per kg.

Turin and in the steel works "Forni Termoelettricità Stassano," in Turin.

I have already mentioned that my furnaces may serve as well for the direct extraction of malleable iron from ore as for the purification of pig iron, scrap iron, etc. This shows their great value for countries lacking in fossil fuel, but rich in

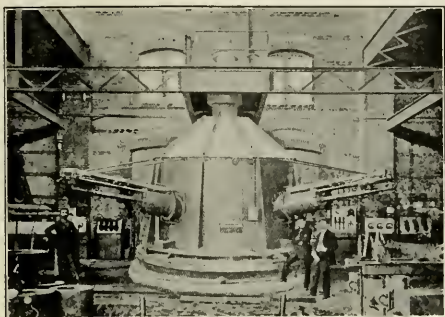


FIG. 8.—ROTARY 1000-HP FURNACE AT STASSANO STEEL WORKS.

water powers. But, although this field of action would be sufficiently large, my electric furnace may also serve an important mission in other countries as a valuable auxiliary to the common iron and steel industry, using blast furnaces, Bessemer converters and open-hearth furnaces.

The progress of modern industry requires iron and steel of highest quality and purity, which cannot be obtained by the common processes or only approximately so, by employing the purest ore, which not only is costly, but scarce.

Under these circumstances, the electric furnace has arrived just in time to help the old iron and steel industry, since its particular properties allow to refine the products of the old furnaces and to carry them to that perfection which the industrial application requires. The consumption of electrical energy is so reasonable that the furnace may even be used conveniently where electricity is produced by coal.

To prevent unnecessary criticism it is well to keep in mind the clear division of the application of the electric furnace into

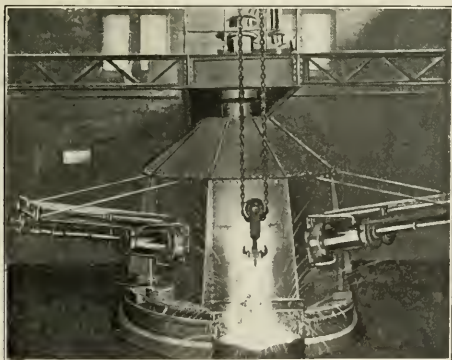


FIG. 9.—CASTING WITH A ROTARY FURNACE OF 1000 HP.

two distinct fields, one being iron-ore reduction in countries where ore and water power are abundant and at a cheap price, while mineral fuel is lacking; the other application is the purification of common furnace products produced in large quantity in the ordinary way by blast furnaces, etc., in order to obtain

a very refined material which heretofore could be produced only with difficulty from the purest ore, of which certainly there is no abundance.

Both plants in Turin, that in the artillery shop and those in the Stassano steel works, are normally treating pig iron and scrap. The latter works are chiefly producing castings of mild steel for automobiles, railway wheels and castings for general mechanical purposes. On various occasions, however, successful conversions of ore into malleable iron and the refining into special steel of finest quality have been carried out.

The erection of the plant "Forni Termo Elettrici Stassano" began towards the end of 1905, and ever since then the furnaces of 100 and 200 hp have been in regular operation, while those of 1000 hp made a sole campaign each, proving the convenience of types of such large size. The only reason why they have not been used continuously in regular operation is, that the entire plant has not yet been completed so far as to take care of the output of the 1000-hp furnaces.

The consumption of energy reported in tables C, D and F as the results of regular industrial operation, are average

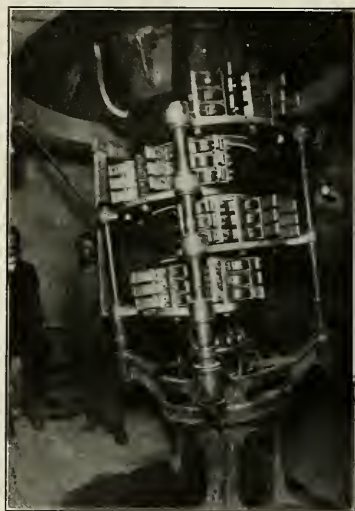


FIG. 10.—COLLECTOR OF 1000-HP ROTARY FURNACE.

values of the operation extending over one year, or over a complete campaign, as indicated, while the figures in A and B give the consumption as measured in each case by the meters. The average values for a year are higher than the values obtained in single tests on account of various factors which interfere, though they have not directly to do with the strict requirements of the furnaces. After all, the values are all correct and offer a reliable basis for practical calculations.

Further, in examining the figures of the different tables, one has to consider the size of the furnace, which influences the consumption of energy; it is clear that a small furnace will consume more power per unit of output than a bigger one. For instance, in the refining of steel in the 220-hp furnaces at the Steel Works Stassano (average of 1907) 1.26 kw-hours were consumed per kilogram of steel, while 2.3 kw-hours were required with the furnaces of 100 hp.

The construction of the furnace is the same whether it is used for iron reduction or steel refining, with only slight alterations for special purposes. For instance, for refining iron and steel, cold or hot, it is possible to omit the top escape for the gases and the sand and water valves.

Further, with my furnace we are not limited to the treatment of rich ore, but can deal likewise with inferior qualities, be they inferior on account of the percentage of iron or of the content of the impurities.

Sheet C refers to castings where it was possible to find the

of interest, since from them the figures were obtained which are given in tables A to F.

The first plant erected was that ordered by the Italian Minister of War for the Artillery Works, at Turin. It contains a furnace of 200 hp (Fig. 3) operated by three-phase currents from the supply network of the Societa Elettricit  Alta Italia. An underground cable brings current of 3000 volts to the transformer, where it is reduced to 80 volts between two phases, delta-connection being used. The operation began in spring, 1903, and ever since then the furnace has been in regular operation, making use of the excess of energy produced by water power during the high-water season, which lasts eight months in a year. This results in cheap power for the production of about 2½ tons of steel daily.

The second plant was that of Stassano's Steel Works, at Turin, which at the same time are the only steel works in the world exclusively operated by electricity, and where the whole output is obtained from electric furnaces.

The erection commenced towards the end of 1905 and the plant is now completed. Fig. 4 gives an idea of its arrangement. The first furnace was started in March, 1906, beginning operations before the plant had been finished.

The chief products are castings of iron and steel, while successful trials have been made to produce special steel, which soon will be another branch of the work of the company.

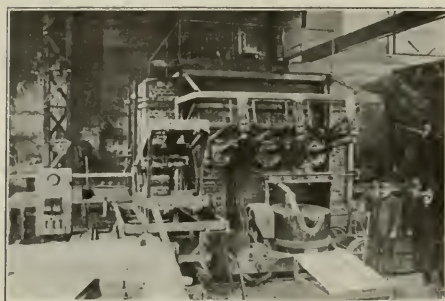


FIG. 11.—1000-HP STATIONARY FURNACE AT STASSANO STEEL WORKS.

exact weight of the output each time; it proves the full recovery of the values of each charge, which is due to the chemically neutral atmosphere in my furnace which impedes any pernicious oxidation and hence any loss of weight.

The possibility and ease of working with predetermined quantities is clearly shown in these sheets, and as the specific consumption of electrical energy per unit of output decreases with the increasing size of the furnace and is within modest limits already with furnaces of 200 hp, the economy of their employment is demonstrated.

The consumption of electrodes, expenses for repairs and insulation and salary expenses are low, as experience has shown. During the long operation in the Artillery Works and in Stassano's Steel Works the consumption of electrodes was not more than 10 kg per ton of output; the expense for lining per ton of output was in the average 10 lira (about \$1.93), except some rare special cases where it rose to 14 or 15 lira (about \$2.70 to \$2.90) per ton. As to the wages, three men will be quite enough for a furnace of 300 hp, and five men, at the utmost six, may attend to a furnace of 1,000 hp when working



FIG. 13.—ROTARY 250-HP FURNACE OF BONNER FRAESER FABRIK.

At present there are installed two furnaces of my system of the stationary type, each of 100 hp, which are generally used for experiments (Fig. 5), two furnaces of 200 hp each, one tilting and the other rotary (Figs. 6 and 7), and two furnaces of 1000 hp each, one stationary (Fig. 11) and the other rotary (Figs. 8, 9 and 10).

The energy is furnished by the Societa Alta Italia from the public supply mains in form of three-phase currents at 21,500 volts. The voltage is reduced in the works by transformers to 80 volts for the furnaces of 100 hp, which are single-phase, and to 100 volts between two phases, delta-connection, for the 200-hp furnaces, for general power purposes and for lighting, and to 150 volts between two phases (delta-connection) for the 1000-hp furnaces.

The works employ about 300 men. There is a complete hydraulic molding plant, hydraulic crushers, air hammers, a repairing shop and finishing tools and sand blast for the castings.

Like the artillery works, this plant also makes use of the excess of energy produced from water power during the high-water season. The production is, therefore, arranged in such a way that during these eight months one of the two 1000-hp furnaces is also in operation, while during the other four months only the two furnaces of 200 hp are working, besides the other machinery.

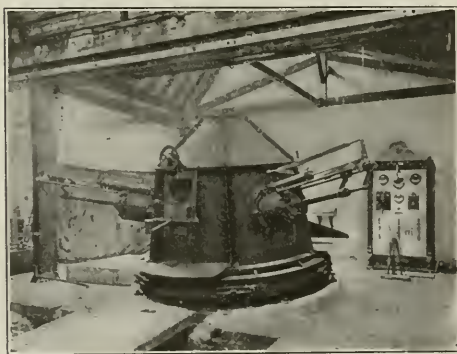


FIG. 12.—ROTARY 250-HP FURNACE OF BONNER FRAESER FABRIK.

with cold material, while for refining steel or reducing ore four men will be sufficient.

Finally a description of the plants using my furnace will be

Some months ago a rotary furnace of 250 hp (Figs. 12 and 13) has commenced regular operation at the Bonner Fräser Fabrik, in Bonn-on-the-Rhine, Germany, and produces castings of mild steel and special steel. It is fed with three-phase currents from the Berggeist-Brühl Electricity Works, which are steam driven. The voltage supplied is 5500, which is reduced by the transformer near the furnace to 100 volts between two phases.

TURIN, ITALY.

Changes in Magnetic Properties Occurring at the Thermal Critical Points in Steel.

In the article of Dr. H. M. Boylston, published in our July issue, pages 273 and 274, reference was made to two tables giving the results of the use of the method. By an unfortunate mistake these tables were omitted. They are given below.

Table I gives the results obtained by Dr. Boylston and an assistant, using the magnetic method as compared with results obtained by a class of advanced students, using pieces of the same steels and the cooling-curve method.

Table II gives results obtained during the past two years by a large class of students who had no previous experience with the apparatus.

TABLE I.—COMPARISON OF THE MAGNETIC METHOD WITH THE ORDINARY OR COOLING-CURVE METHOD.

Approximate carbon content of steel.	Method.	Ac 3-2-1		Number of Tests	Ar 3-2-1		Number of Tests
		Mean	Max. Min.		Mean	Max. Min.	
1.25%	Magnetic...	773	788	7	708	711	7
			759			706	
	Ordinary...	764	781	4	718	736	4
			754			701	
0.40%	Magnetic..	Ac 3-2		7	Ar 3-2		7
		780	790		741	750	
			770			734	
	Ordinary..	827	830	3	754	756	3
			822			753	
0.15%	Magnetic...	Ac 2		6	Ar 2		7
		764	772		764	771	
			755			758	
	Ordinary..	768	772	2	767	783	3
			764			748	

TABLE II.—RESULTS OBTAINED BY STUDENTS AT HARVARD UNIVERSITY.

Steel Number	Method	Ac 3-2-1	Number of Tests	Ar 3-2-1	Number of Tests
1	Magnetic.....	753	72	679	75
	Ordinary.....	739	14	688	12
2	Magnetic.....	752	131	695	136
	Ordinary.....	750	13	695	17

Ferroboron Prize—The conditions of the prize competition for an award of \$500, offered by the Pacific Coast Borax Co. have just been made public by the American Electrochemical Society, which will make the award. The process of making ferroboron must represent an improvement on present methods. We will publish the complete rules of the competition in our next issue.

Silicides for Containers of Acids

At the last meeting of the Faraday Society a paper on new applications of electrometallurgical alloys was presented by Mr. Ab. Jouvé, consulting engineer in Paris and director of the *Revue d'Electrochimie et d'Electrometallurgie*.

Among the alloys prepared in the electric furnace the most important are those containing iron, and particularly the ferrosilicons.

Electric-furnace ferrosilicons contain a percentage of silicon varying from 20 to 75 per cent, the most usual brands being 20 to 25, 50 to 55 and 70 to 75 per cent.

Their uses are well known to all metallurgists, while the analytical methods for determining them are very numerous, accurate and wholly without complication, being all based on the solution of the substance in alkalis in the presence of an oxidizing agent, such as peroxide of sodium, sodium oxide or free oxygen.

It is a fact well known to analysts that no methods of analysis are based on the effect of acid, except in the case of hydrofluoric acid, ferrosilicons with percentages above 20 per cent being insoluble in acids.

It is this peculiar property, due to silicon alone, which enables one to use ferrosilicon apparatus as containers of acids, since they are practically unaffected by the acid.

Ferrosilicons are not, however, the only substances which possess this property. For, as the effect is due to the silicon, any alloy of a metal with silicon will behave in the same way to a greater or less degree according to the nature of the metal. For instance, that calcium silicide will be unaffected by acid; it is much less affected by acids than metallic calcium.

It seems, therefore, important to investigate whether containers for acids, made from metallic silicides, will be satisfactory for this purpose in other respects. The following facts must be taken into consideration: (1) That these substances are very fragile; (2) they contract considerably on cooling, often breaking in the mold when scarcely solidified and still at a bright red heat; (3) their melting point is low compared with the temperatures occurring in ordinary foundry practice, *e. g.*, the second melting in a coke or gas-heated cupola, and (4) certain of these compounds are powerful reducing agents, so that an effect similar to that produced by aluminium may occur.

In consequence if fusion is carried out in the presence of air (which is necessary for combustion of the coke or furnace gas) there will be a considerable loss of silicon and reduction of the percentage of silicon (especially in rich ferrosilicons, *i. e.*, about 35 per cent) to a point sometimes as low as 15 per cent. But such low-silicon alloys are attacked by moderately strong acids.

Manufacture of Apparatus.—It is not proposed to enter here into complete details of the foundry methods employed, and it may simply be stated that by special arrangements and after many experiments on the mechanical properties of alloys of different natures, it has been possible to obtain, after six years' research, apparatus of all kinds and descriptions.

The first part of the process consists in obtaining melted metal suitable for pouring into molds. The simplest method is to pour the prepared alloys directly from the electric furnace into a mold with a refractory lining. The mixture with other desired elements is then made. In another method, the alloys obtained from the electric furnace are remelted in an oil furnace, or in certain cases in a crucible furnace, and then cast into ingots.

Metals for corrective purposes are added directly to the metal in the casting ladle, usually with aluminium, which raises the temperature of the bath and increases the fluidity.

When the ladle is ready it is carried quickly, by a traveling crane, to prevent cooling, to the mold. The pouring does not require special precautions.

The casting is removed as soon as it solidifies, is turned out

into the warm casting sand and annealed at a bright red heat. It is then ready for use.

Resistance to Acids.—The resistance of the metallic alloys of silicon, which have been called "Métillures," to acids is quite interesting, as will be seen from the following examples. Nitric acid, even as a vapor, such as is obtained at the exit of a bisulphate retort, or when mixed with nitrous acid, does not affect them at all. A striking example of this is given by a pipe which has been submitted for nearly five years to the daily passage of 660 lb. of nitric acid vapor at temperatures varying from 150 deg. to 200 deg. without its loss in weight exceeding a few decigrams in a total weight of a score of kilograms. This loss occurred quite at the beginning of the period and was probably due to a few impurities remaining at the inner surface of the pipe after fusion.

Sulphuric acid has still less effect, and "acids of strength from 20 to 25, known as *petites eaux*, may be concentrated in vessels of this kind by direct heating and continuous evaporation."

Hydrochloric acid is analogous in its action and use has been made of pipes of the above material for carrying and condensing its gases.

Acetic acid and the mixture produced by treating calcium acetate with sulphuric acid are without effect on "Métillures," even in the presence of air.

Resistance to Other Reagents.—An important English firm has obtained figures relating to the resistance of "Métillures" to the action of cyanides, sulpho-cyanides and prussic acid. The results show that the unattackability increases with the percentage of silicon and that for a suitable percentage it is practically negligible.

"Métillures"—20 per cent. Nitric Acid.

No.	Weight in grms.	Change in weight. After 24 hours.	Reaction with Sulpho-Cyanide.
1	6.4410	—0.0392	Violent.
2	5.1666	—0.0047	Slight.
3	8.1524	—0.0037	Moderate.
4	14.5013	+0.0012	Moderate.
5	1.7060	—0.0716	Very violent.
6	1.4941	—0.0034	Very slight.
After 48 hours.			
1	6.4018	—0.0207	Violent.
2	5.1622	—0.0006	Very slight.
3	8.1487	—0.0032	Moderate.
4	14.5025	+0.0045	Slight.
5	1.6344	—0.0323	Violent.
6	1.4907	—0.0007	None.

Métillures—13 per cent. Sulpho-Cyanide of Aniline.

No.	Weight in grms.	Change in Weight.	Reaction with Potassium Ferri-cyanide.
After 24 hours.			
1	6.3811	—0.0387	Very violent.
2	5.1616	—0.0065	Moderate.
3	8.1455	—0.0455	Violent.
4	14.5070	+0.0055	Slight.
5	1.6021	—0.0186	Violent.
6	1.4900	—0.0160	Very slight.
After 48 hours.			
1	6.3430	—0.0675	Very violent.
2	5.1551	—0.0219	Moderate.
3	8.1000	—0.0433	Violent.
4	14.5125	—0.0063	Slight.
5	1.5835	—0.0216	Violent.
6	1.4740	—0.0011	Very slight.

Under the same conditions, iron or any other metal in commercial use would be rapidly attacked, thus preventing its employment. Métillure apparatus, as now constructed, vary greatly in form and dimensions; they are used for evaporating dishes, troughs, right-angled bends, elbows, worms, ventilators, etc. Some of these apparatus weigh about 20 lb. and have a diameter of 1 ft., while others weigh over 1 ton and measure 7 ft. across, while pipes with a diameter of 8 ft. and weighing about 34 tons are made.

To sum up, the production of a material capable of resisting acids is an accomplished fact, and the principal desiderata are realized. It remains, however, to remedy the unmalleability of these materials. This question is actually being studied, and a solution seems probable in the near future.

Without the electric furnace the high-percentage alloys of metals with silicon cannot be manufactured. Further, without an electric furnace the fusion of high-percentage silicides is

not possible. For when the percentage of Li exceeds 50, the temperature of a coke or gas furnace is not sufficient to permit these alloys to be cast; they will not leave the crucible, but form a pasty mass.

This latest achievement of the electric furnace is timely. For platinum, the most stable industrial metal, becomes more and more rare, and its price increases by leaps and bounds, making its employment a matter of greater and greater difficulty.

Metallurgical Calculations.

By J. W. RICHARDS,

Professor of Metallurgy in Lethbridge University.

In the "Introduction" written to the first number of these calculations, in March, 1905, the author outlined the program which he hoped to cover, and mentioned the topics he intended to discuss. The last item on the schedule was "Condensation of Metallic Vapors: Principles involved. Application to the condensation of zinc and mercury." The installment in the last number of this journal covered this topic, and apparently brought the writer to the end of his program.

There are other metals commercially manufactured, however, than those so far mentioned in these pages, and it is worth considering whether any of them furnish problems inviting calculations different from any so far discussed. We have, in fact, covered in Parts I, II and III practically all the metallurgical principles capable of quantitative investigation and expression, and what remains undone is the application of these principles to further special cases.

METALLURGY OF ALUMINIUM.

The two essential principles here involved are "differential reduction" as used in the electric furnace purification of alumina, and "electrolytic furnace operation," as illustrated in the decomposition of the alumina by electrolysis in the manner usually practiced. Only the latter problem will be covered here.

ELECTROLYTIC FURNACE REDUCTION OF ALUMINA.

The Hall process is beautifully simple and technically admirable. Al_2O_3 is found to dissolve in melted alkaline-aluminium double fluorides; it is as pretty a case of solution, so far as appearances go, as dissolving a spoonful of powdered sugar in a glass of distilled water. The melting point of the fused fluorides is reduced by the solution of alumina, just as that of water is reduced by dissolving salt. In passing the electric current the constituents of the dissolved alumina appear at the electrodes, oxygen at the anode and aluminium at the cathode. The best practical arrangement is to use a carbon-lined pot, with molten aluminium in the bottom as the cathode, upon it a few inches depth of the bath, and dipping into this the carbon anodes. The writer has given most of the technical details of this operation in his treatise on "Aluminium," and Prof. Haber has published extensive laboratory studies of the process in the *Zeitschrift für Elektrochemie*.

With a solvent salt consisting of melted sodium fluoride and aluminium fluoride, such as called for in one of the Hall patents, with alumina dissolved therein, and using carbon anodes, the electrolytic elements of the process are simplicity itself. The bath contains sodium, aluminium, fluorine and oxygen, and the anode is carbon. Under these conditions those elements or compounds will form at the electrodes which cannot further react upon the bath material; in other words, those materials most stable in contact with the bath material or electrodes. A moment's reflection explains what happens, and what must happen. At the cathode, sodium cannot be liberated because metallic sodium reacts chemically on this bath, separating out aluminium; therefore, the electrolytic reducing tendency at the surface of the cathode can only expend itself in separating out aluminium. At the anode, fluorine cannot be liberated because fluorine acts strongly upon alumina even when cold, converting it into fluoride and expelling its oxygen; therefore, the electro-

lytic producing tendency at the surface of the anode will tend to set free oxygen. But oxygen cannot be set free at a carbon surface at a cherry-red heat because of its inevitable tendency to unite with the carbon to form CO. The electrolytic agency at the surface of the carbon anode must, therefore, cause the formation of CO. The whole electrolytic operation results in the removal of Al^+O^3 from the bath and the formation of aluminium and carbon monoxide.

The thermochemical relations, as far as known, agree absolutely with the above explained experimental results. The materials in presence of each other are sodium fluoride, aluminium fluoride, aluminium oxide and carbon. The heats of formation of these, per molecule and per chemical equivalent concerned, are as follows:

(Na, F) = 109,720 = 109,720 per chemical equivalent.

(Al, F³) = 275,230 = 91,740 " " "

(Al³, O³) = 392,600 = 65,430 " " "

(C, O) = 29,160 = 14,580 " " "

The heat of formation of carbon tetra fluoride is unknown, but is probably small, since it is so difficult to form.

From the last column, which largely governs the work done by the current, we see that the current does far the least work when it decomposes alumina; in fact, it does still less, by 14,580 calories, because of the assistance rendered by carbon uniting with the oxygen. Now, although the electrical current does not consistently adhere to the doctrine of "least work," yet it does in this case because forced to do so by the chemical relations of sodium, aluminium, fluorine, oxygen and carbon at the temperature of the bath, as explained in the preceding analysis. It is probable that in electrolysis the chemical relations of the possible products control what the current does rather than the thermochemical relations alone, but in most cases the two conditions or controlling circumstances coincide in their influence and lead to identical results. This is the case in the process in question; it is absolutely normal and is explainable by either method of reasoning.

If the operation is run with a small vessel and correspondingly small current, the heat necessarily evolved by the passage of the current is small compared to the conduction and radiation losses and must be supplemented by outside heating to keep the contents at proper temperature. If the size of the operation is increased in all its items and dimensions, the necessarily generated internal "resistance" heat will suffice to keep the bath at the requisite temperature, when the enlargement is done on a certain scale. If enlarged past this point, too much internal heat is unavoidably generated and means must be used to artificially cool the pot.

Problem 140.

An electrolytic vessel is composed of a block of carbon 25 cm cube, with a cavity 10 cm square by 10 cm deep inside. The cavity has a round carbon, 5 cm diameter, dipping into it. The vessel weighs 30 kilograms: the fused bath in the cavity 2 kg; the carbon immersed in it 0.1 kg. The specific heat of the carbon is 0.5, of the bath 0.3, at the running temperature. An experiment showed that the bath material cooled off, at the working temperature, at the rate of 10° C. per minute, the walls of the vessel at an average rate of 2° C. per minute, when left to cool by themselves.

Required:

(1) The number of watts which must be converted into heat in the vessel in order to maintain it at the working temperature.

(2) Assuming 75 per cent of the theoretical ampere efficiency to be obtained, what amperes passed through the pot will keep it at working temperature if the working voltage is kept at 10 volts?

Solution:

(1) The 30 kg of vessel material losing heat at the rate of 2° per minute, with specific heat of 0.5, gives a heat loss per minute of

$$30 \times 0.5 \times 2 = 30 \text{ Calories.}$$

Similarly, the immersed carbon in the cavity and the bath material itself lose

$$0.1 \times 0.5 \times 10 = 0.5 \text{ Calories.}$$

$$2.0 \times 0.3 \times 10 = 6.0 \text{ "}$$

The total heat loss is, therefore, 36.5 Calories per minute.

To maintain the temperature constant the current must furnish this heat, and since 1 watt is 0.239 gram calories per second, the watt energy thus converted into heat must be

$$\frac{36.5 \times 1000}{0.239 \times 60} = 2545 \text{ watts} \quad (1)$$

(2) If all the amperes passing through separated out metal the voltage absorbed in decomposition in the bath would be from the thermochemical heats of formation of chemical equivalent quantities of Al^+O^3 and CO:

$$\frac{65,430 - 14,580}{23,040} = 2.2 \text{ volts.}$$

If 75 per cent of the amperes are efficient, the voltage thus absorbed is

$$2.2 \times 0.75 = 1.65 \text{ volts.}$$

The voltage disappearing in overcoming ohmic resistance will then be

$$10 - 1.65 = 8.35 \text{ volts}$$

and the current which when passed will keep the pot at working temperature will be

$$\frac{2545}{8.35} = 305 \text{ amperes.} \quad (2)$$

The above-used principles are applicable to any kind of electrolytic-furnace operation.

Hard Spots in Steel Castings, with an Account of Certain Diffusion Phenomena.

By ARTHUR P. SCOTT.

(Concluded from page 286.)

We can now trace, with a very tolerable degree of certainty, the hard spot and blowhole in our roll to their true source.

A lump of ferro failed of perfect admixture in the ladle (the ways in which this could happen will be pointed out farther on) and, in the form of a molten globule or lenticular mass, constantly absorbing iron and gas from the steel, it passed through the ladle-nozzle into the runner, through the gate and into the mold, just as the surface of the molten steel had reached the thrust collar level. Obeying its upward and outward impulse, it flew to the circumference, and was caught in the recess at the point described, where, as can be seen, it would be chilled almost instantly, and where the continued dilution, with absorption and liberation of gas at its interior, led to exactly the condition we have reproduced experimentally in heats 24 and 25.

Since iron and manganese in the molten state are mutually soluble in all proportions, it was now argued that the cause of the sharp dividing line maintained throughout between steel and ferro, was probably rather a function of the relative concentration than of any property inherent in the manganese itself, and that therefore the same phenomena might be expected if a fragment of pig-iron were substituted for the ferro in a heat of soft steel; that if it did, there would be the additional advantage that the more familiar and better defined microstructure of the iron-carbon alloys would render it possible definitely to determine whether or not there occurs any emigration of the carbon before the solidifying point is reached and cementation sets in.

Briefly, two tests made in this way—heats 26 and 27—exhibited exactly the characteristics shown in Fig. 4, the sac being composed of altered pig-iron instead of altered ferro. Also the blowholes were larger than before. Photomicrograph

5 shows a portion of the apex of blowhole A, heat 26. (Microphotographs 5 and 6 and Fig. 4 will be found on pages 284 and 286 of the July issue of this journal.)

The lower part of the picture exhibits the distinctive appearance of a residual meshwork of cementite, surrounding patches of pearlite. The original pig iron is seen to be well on its way to the eutectoid stage, and must therefore have suffered much dilution. Next comes the boundary line, quite sharply marked, which defines the partition of steel from iron at the moment of solidification.

Beyond this is a dark band of pearlite, or rather, perhaps, of sorbite, passing sharply into the almost pure ferrite of the original steel. On following it up in the original section, we found places where the dividing line died entirely away, having been obliterated by the progress of the cementation that set in, presumably, immediately upon solidification.

Photomicrograph 6 is taken from the under side of blowhole B, heat 26. At the top appears the ferrite of the soft steel; next, a sorbitic area with a meshwork of ferrite; next, a band of pearlite, and finally, in the lower portion, a fine meshwork of cementite surrounding patches of pearlite. Cementation has been longer at work, and the dividing line has disappeared. Globules of the altered iron that were found in the upper part of the test ingot, shaded into the steel in the same way.

To revert for a moment—there appears in microphotograph 3 and notably in No. 4, a dark band on the steel side of the partition which is more readily understood in view of what has just been said of carbon cementation below the solidifying point. In every one of these cases the short distance the carbon has travelled and the undisturbed parallelism of the outlines of the carbon beach to the parent cliff of iron or ferro—if one may be permitted to imitate Dr. Howe in his graphic use of geographic simile—tend to bear out what has already been indicated, viz., during cooling, down to the point of solidification, the migration is wholly one of iron and gas molecules towards the region of greater concentration and of lower melting point; after solidification the tide turns, as it were, and carbon migrates in the opposite direction.

So thin and so closely adherent to the steel were the walls of the blowholes in heats 26 and 27, that no attempt was made to isolate the altered iron for analysis. Neither could reliable drillings of the steel be obtained. One complete pyramid test was made, however, using pig-iron and rail-steel, and here, as was to be expected, the whole pyramid remained in situ, as in heats 20 to 22 inclusive, and was readily separated and crushed for analysis. The results were as follows:

Heat No. 28. Weight of ingot 1368 g. Weight of pyramid 19.4 g.

	Total. Carbon.	Phosphorus.
Original (gray) pig-iron.....	3.76	1.56
Altered (gray) pig-iron.....	2.84	1.07
Regular test—center drillings.....	.64	.04
Pyramid test—center drillings.....	.66	.045

Arnold and MacWilliam (Jour. Iron & Steel Inst., 1899-1-85) classify carbon, sulphur and phosphorus in iron as migratory at a temperature of 1000 deg. C. Manganese, they pronounce fixed under the same conditions. They state that the velocities of diffusion of carbon and phosphorus under the conditions they describe are to one another as five to one. This being the case, the phosphorus in our heat 28, would scarcely have diffused sufficiently far into the steel to be included in our drillings of the latter.

By way of more or less crude confirmation of their findings with regard to manganese, we packed three polished blocks, each about 1.5 cm cube in powdered ferromanganese contained in as many 50 cc porcelain crucibles. Cube A was of wrought iron. B was of steel with 0.18 per cent carbon and 0.38 per cent Mn. C was of steel with 0.60 per cent carbon and 0.85 per cent Mn.

We next filled the crucibles to the top with the powdered ferro, tamped them well down and covered each with a seal of

well packed dry fire clay. The three crucibles were then gradually heated in an electric muffle controlled by a Le Chatelier pyrometer, to 1000 deg. C., and held at that temperature (± 40 deg.) for twenty-four hours. During the next three hours the muffle temperature was raised to 1220 deg. C. The current was then cut off, and the furnace allowed to cool.

Chemical and microscopic examination proved conclusively that there had been no migration either of manganese or of carbon, from the ferro to either of the three cubes, which is distinctly interesting in view of the undoubted carbon migration from ferro to steel on cooling from the freezing point, as shown in photomicrographs 3 and 4. But to be considered of significance with reference to the department of manganese—iron carbides at high temperatures, the result of our crucible experiment would have to be confirmed—perhaps best by fusing a small core of ferro into an iron barrel, somewhat along the lines suggested for sulphur by T. W. Hogg in the discussion following Arnold and MacWilliams paper (loc. cit., p. 126), and suitably heating the test piece so prepared.

Returning to the pyramid experiments, the writer realizes that the number of these which were carried out is not great, but would remark:

1. That the work has been done in the occasional intervals permitted by duty.
2. That the special Mn test is a hard nut to crack. Great care and patience must be expended in getting at the kernel.
3. That the experiments all pointed so definitely in the same direction as to make mere repetition seem superfluous.
4. That the foregoing descriptions are not selected material. Every bit of work that was done in this connection has been faithfully chronicled here, and every analysis recorded.
5. That all samples for analysis were prepared with the utmost care under the writer's personal supervision, and that the chemical work was performed by competent and experienced analysts.¹

Practical Considerations.

We are scarcely in a position to say that all superficial hard spots associated with blowholes in steel castings would reveal on closer examination the characteristics described for the subject of this investigation; nor, if we could so assume, would we perhaps be altogether justified in definitely stating that all such hard spots are due to badly distributed ferro. At the same time, there is much well-known evidence of a general character, which in conjunction with the foregoing, enables us to conclude that the number of hard spots and other irregularities caused by imperfect diffusion of the ferro, is far greater than is generally believed.

As is well known, manganese additions to basic open-hearth steel by means of the molten spiegel employed in Bessemer steel-making, are not practicable. Ferromanganese, therefore, is added, either "through the furnace" just before tapping, or else, either cold, or preheated to redness, in the ladle after tapping. The method of addition through the furnace entails heavy manganese loss—a loss which does not seem to be offset by any definite advantage of any kind, because if the ladle additions are properly made, perfect distribution is absolutely assured. There are, however, certain conditions which may be productive of bad results in this respect.

1. If the tapping hole be too large, slag is very apt to come before all the ferro is in.

2. Cases have been known where the mill foreman deliberately waited for nearly all the steel before finishing his manganese addition, with a view to forming a closer estimate of the ladle content, and thereby more nicely adjusting the amount of ferro to be added. This is a most glaring example of "straining at a gnat and swallowing a camel."

3. Occasionally, while carbon and manganese additions are in progress a heavy "boil" is produced in the ladle, accom-

¹Messrs. I. C. Mackie, G. MacPherson and W. Tiddy.

panied by such a scorching blast of flame, that the helpers are for a few seconds compelled to desist from their shovelling.

In each of these three cases, some of the ferro falls on top of the slag, in which event it is mechanically held up by the latter, or, if it break through, has lost its impetus, slides gently upon the surface of the steel, fuses, and spreads over it as a distinct layer. This we may safely infer from heat 23 above, and from the general tendency observed in heats 24 and 25.

By this time the ladle is fairly tranquil, so that the layer of molten ferro is more or less undisturbed, the diffusion of iron into it is relatively slow, and perhaps half of the ingots are teemed before merging is effected. As a result, the first half of the heat is short of manganese, while the latter half carries an excess.

If the heat be completely teemed before merging have taken place, the alloy, as soon as it reaches the last ingot-mold, breaks up into globules, which promptly fly to the cooling surfaces and solidify there, forming hard spots.

H. H. Campbell, in his third edition, page 281, supposes a case where a lump of ferro is held up on the slag until shaken through by the disturbance incidental to teeming, etc. The writer has not yet noticed this passage in the fourth edition of Mr. Campbell's work.

4. If the ferro be added in lumps so large that merging does not take place before they can rise to the surface, the tendency will be the same as in cases 1, 2 and 3 just cited.

5. If a lump of ferro strike the bottom of the ladle before the stream of steel does, there is great danger, particularly if the tapping-hole be small, that such lump will chill on the bottom with the ladle skull. In this event, we should have an exact repetition of the conditions of our pyramid experiments, and there is every probability that if the pyramid burst during teeming, some one ingot will receive several planetary nuclei of hard spots and blowholes.

A little care will prevent the occurrence of any of these conditions and, if the tap-hole be periodically formed up with steel pipe; if the ferro be not too coarse—in the writer's experience, ferro that will pass a one-inch square mesh is quite safe—if none of it be added until there is, say, nine inches of molten steel in the ladle; if it be then thrown in as rapidly as possible from three or four shovels at once, so that it is well scattered and all in before the slag starts, an ideal distribution is regularly obtained.

The foregoing remarks have reference strictly to 50 ton heats. With the smaller heats made in so many steel foundries, the writer has had no opportunity of becoming acquainted. Obviously, the smaller the heat, the greater the danger of faulty distribution. Preheating is no doubt of some benefit in such instances; also, the hotter the steel is tapped, the more rapid will the diffusion be.

Before leaving the practical side of the question it may be mentioned that patents have before now been granted to the inventors of certain processes for the production of a hard surface at any desired point in a steel casting by placing a quantity of manganese alloy in the corresponding portion of the mold previous to pouring. Our pyramid experiments go to show that in the conduct of such processes, the most careful attention would have to be given in detail, e. g., the killing of the metal etc., in order to get the hard spots without the blowhole.

Theoretical Considerations.

The formation of blowholes in our pyramid tests seems to outline the method followed by the ferro in fulfilling its well known function of expelling gases from molten steel, and suggests that pig-iron also has value in this way. We shall hazard no guess as to the reason for the migration of the gas molecules from steel to ferro.

In casting about for an answer to the question, "Why, if our observations are correct, should the iron molecules migrate into the ferro without any reciprocal tendency on the part of the

manganese molecules?" We are struck by an apparent analogy between this phenomenon and certain phenomena observed chiefly for dilute aqueous solutions—phenomena which led to the conception of the osmotic theory by van't Hoff in 1887. This theory, though it had of late years been vigorously attacked by Kahlenberg and other eminent investigators, has still its staunch supporters among some of the most distinguished scientists of our time, and remains, as it has been ever since its formulation, the basis and ground work of our physical chemistry.

In the light of this theory, it is the creed of the physical chemist that just as a given volume of gas exerts, at a given temperature, an outward pressure directly proportional to the number of molecules it contains and due to the impinging of the molecules on the walls of the containing vessel, so, substituting the solvent for an hypothetical aether, the molecules of a substance in solution exert an outward pressure which, for a given solution at a given temperature is directly proportional to the concentration. This homologue of gaseous pressure is termed osmotic pressure. Not only has it been determined that for dilute solutions the product of the osmotic pressure and the volume is proportional to the absolute temperature, so that the equation $pV = RT$, holds for substances in dilute solution as well as for gases, but, further, that R has the same numerical value in both cases.

At any liquid surface, however, whether that surface be free or in contact with the walls of the containing vessel, there is a normal inward pressure, due to surface tension, many times greater than the osmotic pressure, so that the latter, though great, is not evident at the free surface of the liquid and consequently cannot be determined by the simple direct methods used for gaseous pressures. None the less, whether manifest or not, the osmotic pressure is always regarded as present, and is recognized to be the cause of diffusion of substances in solution.

Diffusion, in one aspect, is that process whereby equilibrium is established between two portions of the same liquid which are of different concentrations with reference to the same solute. When, of the same substance, two solutions of different strengths come into contact, diffusion at once sets in, and continues, at a varying rate of speed, until a uniform concentration is reached, and it is customary to regard this diffusion as an incursion from the regions of higher concentration into those of lower concentration. "Just as in gases, we have movements from regions of higher to regions of lower pressure, so in solutions, we have movements from regions of higher osmotic pressure to regions of lower osmotic pressure. Osmotic pressure we then take to be the driving force in the solution." (Walker's "Introduction to Physical Chemistry," p. 171.)

"And, as osmotic pressure is proportional to concentration, it follows at once that the rate of diffusion, which is conditioned by the difference between the osmotic pressures in two adjacent layers, must also be proportional to the difference in concentration." (Ostwald-Muir, "Solutions," p. 102.)

One of the most striking manifestations of osmotic pressure is the following: If we fill with a fairly strong solution of e. g., cane sugar in water, a cell whose walls are permeable to water, but impermeable to dissolved sugar, and place this cell in a vessel containing a dilute water solution of sugar, water will at once commence to pass through the walls into the cell, i. e., from the weaker solution to the stronger, raising the level of the liquid in the cell, without any passage of the sugar in the opposite direction, and will continue so to pass, if uninterrupted by any other force, until the liquid in the cell is of the same concentration as that in the outer vessel. The cell behaves as if there were a partial vacuum for water in its interior." (Ostwald-Muir, op. cit. 102.)

The transfer of liquid into the cell is in no way due to the membrane, but it is customary to regard the membrane as essential to the revelation of the ever-present osmotic pres-

sure. On the other hand, in the absence of the membrane, simple diffusion would set in, in which case, as already stated, the osmotic pressure is assumed to manifest itself as a driving force; though, from the nature of the case, experiments on diffusion phenomena are exceedingly difficult of execution, and the precise department of osmotic pressure in establishing equilibrium has never been elucidated.

It would therefore be perhaps slightly unorthodox, but certainly not definitely wrong, to assume that in every solution there is always present a partial vacuum with reference to the solvent—this vacuum being, as it were, the expression of the osmotic pressure, and, therefore, other things being equal, proportional to the concentration; and that, when we mingle different strengths of the same solution, the diffusion that takes place does not consist in an impulsion of the more concentrated throughout the weaker portion, but is rather a rush of the solvent from the more dilute portion to satisfy the higher partial vacuum that we may suppose to exist in the more concentrated portion; and that therefore, if it were possible at any moment during the admixture of the two, to instantaneously solidify the whole and differentiate its component parts, we should find separate and distinct portions of the more concentrated solution—already partially diluted by water robbed from the weaker solution—intermixed with portions of the latter, which would have remained unaltered, save for the concentration they have undergone by reason of their loss of water.

We might even go further, and say that each portion maintained its individuality till both were of the same concentration, and that then, and only then, the dividing line between the two disappeared.

As a matter of fact, if we are permitted to follow this line of reasoning it becomes possible, in view of the many analogies between molten metal solutions and ordinary water solutions, to offer a tentative explanation of the phenomena recorded in the first part of this paper.

For, if we look upon ferro-manganese as a concentrated solution of manganese in iron—as it is perfectly legitimate to do—and upon steel as a dilute solution of manganese in iron, and if we assume that such molten solutions possess osmotic pressures—as there seems to be no reason for doubting, more particularly in view of the high temperatures involved, and of the rapidity with which diffusion in such molten solutions is consummated—we may at once conclude, that if a suitable membrane separated molten ferro from molten steel, there would be a passage of the solvent iron through this membrane, from steel to ferro, i. e., from the region of lower to that of higher concentration.

We have already endeavored to show that with a manganese-iron solution, as well as with a carbon-iron solution, such migration of iron did occur, without the intervention of any such membrane.

It might be objected, of course, that ferro-manganese can with equal propriety be termed a solution of iron in manganese, since the terms solvent and solute are here only arbitrarily applied, and that our train of argument is, therefore, worthless. It seems reasonable to suppose, however, that the relatively greater mass of the steel, in which we more definitely regard iron as the solvent, determines the rôle of the ferro in this respect, and that in the instances cited, we are justified in considering ferro-manganese also as a solution of manganese in iron.

At all events, the pyramid experiments are interesting, and more or less unique, as affording a glance at an example of diffusion in molten solution, caught at several stages in the actual process.

Whether or not they have a wider significance, and have a bearing on ordinary diffusion phenomena in liquids, would be difficult to determine.

Dominion Iron & Steel Company,
SYDNEY, N. S.

Experimental Electric Smelting.

By LOUIS D. FARNSWORTH.

This article may be of interest to those making initial experiments with electric smelting. It is based on some experiments done by the writer during the first four months of 1908 at Stanford University, California. The experiments were carried out to learn some of the fundamental principles of electric smelting and to obtain data of their working. The experiments were done more from a mechanical and electrical view point than from a metallurgical, yet they may be of interest to metallurgists.

It may be well to roughly outline the apparatus at hand. Nine old-style, air-cooled lighting transformers were connected in parallel to deliver single-phase current, a total of

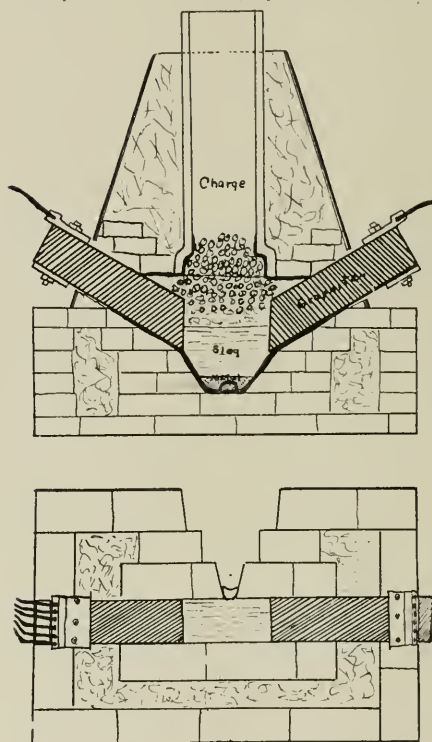


FIG. 1.—ELECTRIC FURNACE.

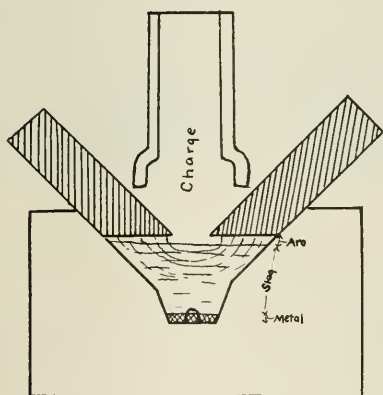
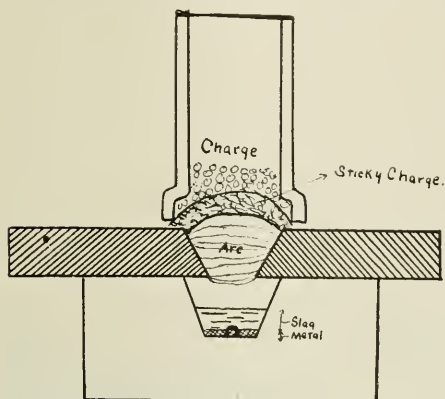
45 kw, at either 50 or 100 volts. A marble panel from an old university lavatory stall was used for a switchboard. It was not of standard size or shape, but answered the purpose. On this piece of marble were mounted reliable voltmeters and ammeter and necessary oil and knife switches. Two 1000-ampere cables carried the current from switchboard to furnace.

Various styles of furnaces were built and tried. The first one of interest is shown in Fig. 1. It was essentially a crucible, covered by a charging stack, and in the sides of which were inclined two graphite electrodes. The crucible was made of magnesite brick. A good mortar was found to be one part Portland cement, one part silica sand and one and a half parts of fireclay. The inside cavity of the crucible was rectangular in plan, 8 in. by 4½ in., having a depth of 4 in. At the end of the crucible were built two 4½ in. by 4½ in., 30° inclined shafts through which the 4 in. by 4 in. electrodes were operated. Outside the crucible was built a brick shell, the space between

being packed with ashes to retain the heat in the crucible. At the bottom of the crucible was made a small tap hole through which the contents of the crucible could be tapped out.

Directly over the opening of the crucible was placed a terra-cotta sewer pipe which was used as a charging and preheating stack. In this stack the charge was preheated and the ore partly reduced. The entire upper part of the furnace was enclosed in a sheet-iron shell. All space between sewer pipe and iron shell was filled with ashes.

The entire inside of furnace subject to heat was coated with



FIGS. 2 AND 3.—MODIFIED FURNACE CONSTRUCTION.

a quarter inch of lining paste. This lining proved to be a good protection to bricks at any temperature obtainable lower than that of an electric arc. It was of carborundum sand, silicate of soda, fireclay and water.

The electrodes were 4 in. by 4 in. graphite. The ends of the electrodes were sawed off on the bias so that they would form the upper part of the ends of the crucible. These electrodes could be readily moved up and down the inclined shafts to regulate the furnace. Electrode holders were cast and machined brass plates suitable to be bolted tight to electrodes. The cables were first soldered into holes in these plates, but due to the heat of the poor contact were melted out. They were then wedged in with steel screws. The cables were placed in their holes and screws pounded in beside them. This scheme made a very satisfactory connection.

The charge used was magnetite ore of 69 per cent iron, with proper mixtures of limestone and coke. In starting the electrodes were placed close together and charging started. The furnace immediately drew current and melted the charge. As the furnace warmed up and slag rose in the crucible the electrodes were drawn farther apart. In starting, the furnace drew about 150 amperes at 50 volts. In 20 minutes the electrodes were 8 in. apart, and the furnace was drawing the full capacity of transformers, 900 amperes. The furnace continued to draw more current. The slag was cooled down by adding more charge.

It was found at this point that the furnace dimensions were not right to fit the transformer capacity. Eight in. drew too much current. In order to retain the slag bath between electrodes and preheat the charge above electrodes, more transformer capacity was needed or the electrodes needed to be

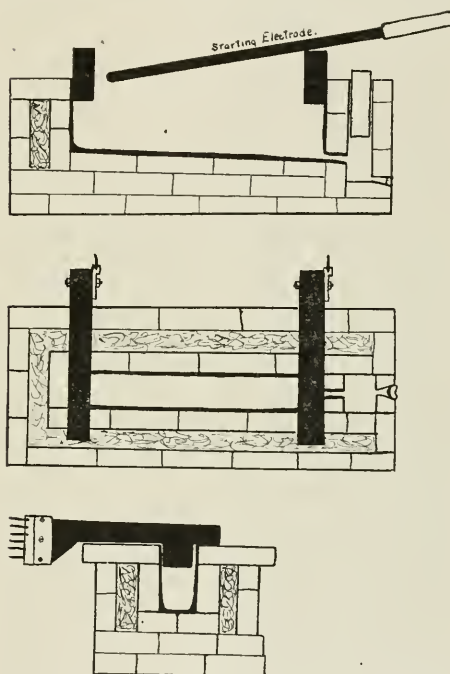


FIG. 4.—FURNACE FOR DETERMINING SLAG RESISTANCE.

farther apart. The design of furnace prevented this. In order to regulate the furnace from this point on the electrodes needed always to be kept at least 1 in. above the slag bath, thus regulating the current with an arc. This arcing does not permit of very long life for the furnace. It is a concentrated intense heat at the wrong place and melts up lining, magnesite brick and in time the whole furnace. By regulating the arc this furnace was found to be able to stand four two-hour runs.

In a two-hour run in which 90 kw-hours were used, 21 pounds of good gray iron was produced. A larger furnace would be more efficient. At the end of a two-hour run it was noted that the hand could be held on any part outside of the furnace except on the electrodes. This shows that the slag bath proposition is all right as soon as the proper dimensions can be obtained. There is lots of opportunity for experimenting along these lines; namely, obtaining data of the resistance of various slags at varying temperature. Some experiments were performed later on to obtain some of this data.

Other types of furnaces tried are shown in Figs. 2 and 3. In the furnace in Fig. 2 the combination of the resistance of arc and the hot charge was used. It was found that a dome of paste charge prevented the feeding of the furnace without trouble.

In the furnace of Fig. 3 the resistance of the combination of an arc and slag bath was used to regulate. The arc in this case is not nearly so destructive as that in the first furnace as it is applied to the upper surface of the slag bath.

An open-crucible furnace was now built, as shown in Fig. 4, to obtain data on slag resistance. It was essentially a brick trough, 24 inches long by $3\frac{1}{2}$ wide and $6\frac{1}{2}$ deep. This trough was built of Carnegie fire brick, lined with a carborundum paste spoken of above. A brick enclosing wall and heat-insulating space was built around the trough as in the first furnace. The bottom of this trough was sloped to one end and to draw off the metal. At this end was built a fore-hearth, $4\frac{1}{2} \times 3\frac{3}{4}$ inches and 9 inches deep into which the metal could be pocketed. A tap hole was provided here to run off metal at proper intervals. The electrodes were cut as shown in Fig. 4, out of graphite, the key end of which hung over into the trough.

In operating this furnace the trough was filled with charge and the electrodes were embedded in the top of this charge about 12 inches apart and power switched on. The charge was made up of cold broken slag, iron ore, coke and limestone. Due to the cold slag and limestone in the charge the furnace drew no current. A charge of coke and ore or coke alone will start the furnace without any help. With the cold slag charge an auxiliary carbon electrode was used starting a melting zone furnace warmed up until the current flowed between the large electrodes.

of about one-half inch and gradually increasing this as the

In starting this furnace considerable arcing took place underneath the electrodes until good contact was made with slag. These arcs form small cavities in sides of bricks retaining a conductive vapor and drawing considerable current, thus generating heat to enlarge the cavity. This destructive arcing did not continue after the furnace was well started.

When the trough was well filled with slag and the furnace running smoothly, the electrodes being 20 inches apart, the current drawn did not fluctuate as much as 5 per cent. It increased slowly but steadily as the slag reached a higher temperature. Ore dropped into the bath rapidly melted. By charging, the temperature could be kept down and the current kept within the 900-ampere limit. If allowed to go beyond this the bath bubbled and sputtered at contact with electrodes and drew an unsteady current.

It was noted during the run that the highest temperatures were near the electrodes, meaning poor contact between the slag and the electrodes. The rate of charging and melting of charge is a factor in determining the distance between electrodes. If no charging was done the distance between the electrodes in order to draw a given current would have to be great enough to afford sufficient radiation to dissipate the heat generated by passage of current. If the furnace was cooled too much by rapid charging the full current could be picked up by lowering a brick plunger in the fore-hearth and forcing a thin layer of metal back into the furnace. The metal was kept molten in fore-hearth by a layer of hot coke above it.

Iron and Steel Statistics.—The statistics of the American and foreign iron trades for 1907 has just been issued by the American Iron and Steel Association. The total production of pig iron in the United States in 1907 was 25,781,361 gross tons (against 25,307,191 in 1906); in Great Britain, 9,923,856 gross tons; in Germany and Luxemburg, 12,875,159 metric tons. The United States production of bessemer steel rails was 3,380,025 gross tons. We comment on these interesting statistics in our editorial pages.

Annual Meeting of the Iron and Steel Institute.

The greater number of the papers presented at the recent annual meeting of the Iron and Steel Institute were abstracted on pages 290 to 297 of our last issue. We now give abstracts of the balance of the papers.

National Physical Laboratory.

A paper by Mr. WALTER ROSENHAIM, of the National Physical Laboratory, describes the metallurgical and chemical laboratories in the National Physical Laboratory, in London. The department is separated into two divisions; one deals with purely metallurgical research work, the other, which is housed in a newly-erected building, deals essentially with metallurgical chemistry.

In the first division the determination of melting and freezing points of metals and alloys, the determinations of critical points and of entire recalcence curves of steel and other metals, and the study of microstructure are regularly undertaken. This division of the department is also frequently called upon to investigate and report upon the causes of failure of parts of structures or machines that have given way or become defective in service.

In the description of the equipment of this division a novel

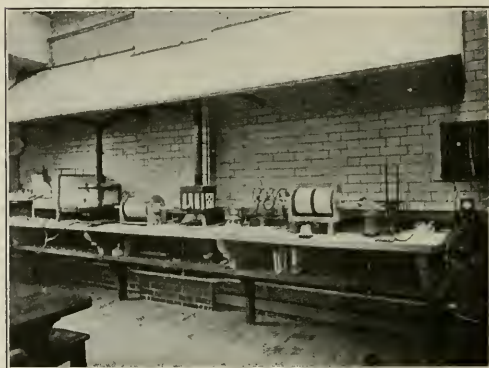


FIG. 1.—COMBUSTION APPARATUS.

form of quenching apparatus is interesting. The specimen of metal to be quenched is heated in a horizontal tube of vitreous silica passing through a shorter electric-tube furnace. One end of the silica tube communicates with a receiver and an air pump, the other end through a bent tube with a vessel of water. After the specimen has been heated to the quenching temperature and the heating current has been turned off, the silica tube is exhausted and the water rushes into the hot tube with considerable force and not only chills the specimen, but sweeps it down the tube away from the heated part into the cold end. In this method the specimen is not exposed to oxidation while being heated, and is not subjected to handling or other manipulation tending to disturb the temperature conditions prior to the sudden quenching which occurs at a definite temperature.

In microphotographic work, the etching reagent most frequently used for steel is a saturated solution of picric acid in alcohol, but nitric acid dissolved in amyl alcohol is also found useful. Means for electrolytic etching are also provided.

Steel analysis is one of the chief operations of the second division devoted to metallurgical chemistry.

The determination of carbon in steel by the process of direct combustion of fine drillings (which must not be coarse) in a current of oxygen has, after careful comparison with other processes, been adopted as the most reliable and at the same time the most expeditious method. While both the Blair and

the direct-combustion methods are perfectly capable of yielding accurate results, there is a greater liability to accidental error in the former, which also requires more complicated apparatus and occupies more time. The very efficient combustion apparatus used is shown at the right-hand end of the stone bench in Fig. 1.

At the right-hand end of the bench stands a large (60-ft.) cylinder of compressed oxygen, provided with four independent fine-adjustment valves mounted on a fitting specially arranged for this purpose. From each of these valves a stout rubber tube carries the oxygen to a drying and purifying system, which is placed on a wooden shelf underneath the stone bench. The system in question consists of a tower packed with soda-lime, followed by a U-tube packed one-half with soda-lime, the other half with calcium chloride, a separate tower and U-tube being provided for each of the four currents of oxygen. From the U-tube the oxygen is carried in rubber tubes to a set of Dreschel bottles containing sulphuric acid; these are placed in a raised position on the stone bench, so as to be visible to an operator manipulating the fine-adjustment valves on the oxygen cylinders; this operator thus has a guide as to the rate at which oxygen is entering the combustion tubes.

The combustion tubes themselves, four in number, are tubes of vitreous (fused) silica, 28 in. in length and $\frac{3}{4}$ in. in diameter; they are heated by a four-tube electric furnace, from which they project by 6 in. at each end; these tubes are closed with rubber stoppers at each end, and these remain perfectly cool and are not in any way acted upon, the only requisite precaution being to protect the inner face of the stoppers at the inlet end from direct radiation from the hot part of the tube; this is effected by the interposition of a short spiral of copper gauze.

Originally the farther ends of these silica combustion tubes were packed with finely granular copper oxide, wrapped in asbestos paper, with a view to preventing the oxide from coming into contact with and acting upon the silica tube. This protection was, however, found inadequate; whenever the temperature of the furnace was allowed to rise a little the copper oxide was very liable to fuse and to eat its way first through the asbestos wrapping and then through the silica tube, which it destroyed completely in a few minutes.

The use of copper oxide has, however, been obviated by the employment of platinized silica. It was at first sought to obtain from the regular sources a supply of platinized quartz wool, but this proved unobtainable, and a trial was then made with fragments obtained by pounding up parts of broken tubes of vitrified silica—these have a more or less rough surface owing to the drawing out of enclosed air-bubbles, and when platinized it was found that the platinum adhered well to the surface. Careful comparison showed that the oxidizing action of this platinized silica was quite as satisfactory as that of copper oxide.

Tubes packed with this material, which is readily renewed at suitable intervals, have now been in use for several months with very satisfactory results, the formerly high mortality of silica combustion tubes being entirely checked. It is a curious fact that while the action of copper oxide on these silica tubes is so very rapid, the small quantities of iron oxide which sometimes find their way into contact with the tubes owing to a fragment of steel being spilled from the boat, do not appear to affect the tube at all. In addition to the platinized silica, the tubes contain the usual lead-chromate packing for the absorption of oxide of sulphur.

The furnace in which the combustion tubes are heated is an electric resistance furnace having four separately wound heating tubes fixed within a single large heat-insulating casing of porcelain tube covered with "magnesia sectional covering." These heating tubes were originally made of porcelain and wound with fine nickel wire, but the furnaces made in this manner were found to require rewinding at intervals of about

three weeks, thus causing a serious loss of time as well as trouble and expense.

A winding of platinum foil on the principle of Heraeus was therefore adopted, and this platinum foil was wound on silica tubes to avoid the risk of destruction by cracking, and also to reduce the deterioration of the platinum by electrolytic action as far as possible. The actual winding is so proportioned that when the furnace is at its proper working temperature (about 1000° C.) the resistance of the tubes coupled up two in series, and the two groups in parallel, is about 14 ohms. From a circuit having a pressure of 100 volts this takes a current of a little over 7 amperes, which is found just sufficient to maintain the desired temperature.

For the purpose of starting up when cold, a switch is provided whereby the four tubes can be thrown into series, thus providing a higher initial resistance. This platinum-wound furnace has now been at work for three months without requiring any attention and shows no signs of any change of resistance.

The steel drillings are introduced into the combustion tubes in long, narrow and very light boats made in the laboratory by the aid of a "boatee" or press made by Messrs. Carling to the design of Mr. Stead. The boats actually employed are made very thin in the wall for the purpose of leaving as large a space available for the drilling as possible, since the dimensions of the combustion tubes which electric heating renders desirable are narrower than usual.

At first some little trouble was experienced in making these boats, but the device of coating the molds of the press with vaseline and interposing a piece of thin tissue paper between the molds and the clay has overcome this entirely, particularly when a specially plastic fireclay from Bavaria is used. The boats, when pressed, are dried and the paper is readily removed, but before use the boats are strongly calcined in a muffle furnace so as to be entirely free from carbon.

From the combustion tubes the gases are led through glass cooling tubes which dip into a large vessel of cold water, and thence into U-tubes of special construction filled with pumice saturated with strong sulphuric acid. These U-tubes are provided with glass stoppers at the top, and with a stopcock at the lowest point of the U. Each day these tubes are filled up completely with fresh acid, which is allowed to remain in them for a short time and is then drained away as completely as possible through the tap at the bottom. This leaves the pumice coated with fresh acid every day, while removing any risk of splashing or bubbling that might arise with any excess acid present.

From these drying tubes the gases are led to the potash absorption bulbs, which are of the ordinary Geissler form. These are carried to the adjoining balance room and weighed in the usual manner. In using this apparatus it is found quite possible for one operator to keep the four combustion tubes completely occupied, with the result that in a working day of from six and a half to seven hours one operator can carry out from eight to ten carbon determinations in duplicate (i. e., 16 to 20 separate combustions), although at times of pressure as many as 12 in duplicate have been completed in one working day.

For phosphorous determination in steel, the original intention was to adopt the very attractive method of Blair (*Jour. Iron & Steel Inst.*, 1904, No. II, p. 239). While it was found that, as a rule, the results of Blair's method were in excellent agreement with those of the gravimetric methods, thus bearing out the results published by Blair, yet at times unaccountable discrepancies would occur. Sometimes these obviously arose from the fact that a small fragment of zinc had been washed down into the titration flask from the "reductor," and when this was seen to be the case the results were obviously and grossly in error; but less obvious errors appeared when no such occurrence could be detected, and the only conclusion appears to be that errors of this kind are liable to arise from the washing down of particles too minute to be observed.

The reduction of molybdic to molybdous acid, as described

by Blair in the method referred to, was therefore abandoned and a modification of the method was tried, which has been described in various modifications by different writers. In the modification adopted in this laboratory, the yellow molybdate precipitate is obtained in the manner described by Blair in the paper referred to above, but instead of being dissolved from the filter with ammonia, the precipitate is washed first with weak nitric acid (2 per cent) and then with a solution (also 2 per cent) of potassium nitrate until the washings are neutral to litmus paper. The filter paper with the yellow precipitate is then thrown into a flask and macerated with a little water. A small quantity of 1.20 normal caustic potash (standard) solution is then added, in which the yellow precipitate immediately dissolves. The excess of alkali is then titrated back with standard sulphuric acid and phenol-phthalein.

The somewhat complicated method of washing with acid and then with potassium nitrate is generally regarded as necessary, as it is supposed that pure water either slightly dissolves or modifies the composition of the yellow precipitate. A series of comparative tests has, however, shown that this supposition is not, perhaps, well founded, the results obtained when the yellow precipitate is washed with water alone being found to agree closely with those obtained by the more elaborate method.

The volumetric method described above gives results only very slightly lower than those obtained by the more elaborate

carbon dioxide obtained by passing a stream of this gas, derived from a cylinder of liquid carbonic acid, through the entire apparatus. The evolved gases, aided towards the end of the operation by a further stream of carbonic acid, are bubbled through an absorption flask containing a solution of cadmium acetate strongly acidified with acetic acid (25 grams pure cadmium acetate and 10 per cent glacial acetic acid per liter); after passing this flask the gases pass through a narrow-bore tube of vitreous silica heated to redness by a Bunsen burner with a flat flame, the gases passing finally through a second cadmium acetate absorption flask and then away to the fume chamber.

When the steel has completely dissolved, the contents of the two absorption flasks are mixed and the yellow sulphide of cadmium is filtered off; this is rapid operation since the flask need not be washed carefully—the operation is merely intended to separate the sulphide from the bulk of the absorption liquid. As soon as this has been done the precipitate is washed from the filter back into the original flask and there dissolved in 10 cubic centimeters of standard iodine solution, the action being aided by the introduction of a small quantity of hydrochloric acid. The excess of iodine is then titrated by means of sodium thio-sulphate and starch.

It is to be observed that while this titration can be carried out in the liquid of the absorption flasks without filtration it has been found that this leads to occasional discrepancies in the results. Apparently, particularly in the case of high-carbon steel, the evolved gases carry into the absorption flask something which is capable of absorbing iodine, but which is not sulphur; this disturbing substance can be eliminated by the filtration described above.

There is a close agreement between the results of the evolution method and Archbutt's oxidation method which has been adopted for check and comparison purposes.

Arsenic is determined by "a well-known evolution method." For manganese a colorimetric method depending on the conversion of manganese into permanganate is employed, the well-known "bismuthate" method being used as a check, while silicon is converted into silica and weighed in the usual manner.

For analytic work on alloys and raw materials required in connection with the metallurgical research work, frequent use is made of electrolytic methods of analysis and a special apparatus has been installed for the electrolytic deposition of metals. The system of electrodes described by Sands (*Transactions of the (Brit.) Chemical Society*, 1907, Vol. 91) has been adopted and a special arrangement for obtaining the necessary rapid rotation of the anode has been set up, together with facilities for the accurate measurement of current and potential. The installation of a capillary electrometer is also arranged for, and it will then be possible to use this apparatus for the electrolytic separation of metals by the method of graded potential.

Pyrometer Installation in a Gun Factory.

A paper by Mr. WESLEY LAMBERT, chief metallurgist of the Royal Gun Factory, Woolwich, describes in detail the very elaborate pyrometric installation in the gun section, Royal Gun and Carriage Factories, Woolwich. Pyrometric control extends in these works over the whole thermal treatment, comprising the heating of the steel for forging operations under the steam hammer or hydraulic press, together with the subsequent annealing, oil-hardening, tempering and shrinkage operations.

The platinum-platinum-iridium thermoelectric couple is used throughout. Each of the larger departments of the works has an independent instrument room fitted with a simple indicating instrument. The galvanometer is of the reflecting type and of simple construction; it is a modification of the d'Arsonval galvanometer, devised by Col. Holden.

Two recording instruments are in constant use day and night in the laboratory. The record is a photographic one. Some slight trouble was first experienced through vibration, but this

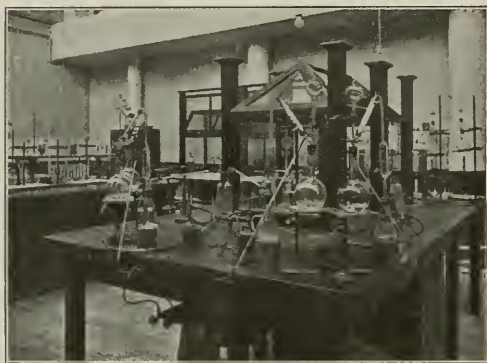


FIG. 2.—APPARATUS FOR SULPHUR DETERMINATION.

and troublesome gravimetric method, the results of the two methods rarely differing more than two duplicate determinations made by either method are frequently found to do. On the whole, however, the results obtained by omitting the potassium-nitrate washing in the volumetric method are found to be very slightly higher than those found when that form of washing is employed, and this difference tends to bring the results still nearer to those found by the gravimetric method. The present practice is to carry out the majority of phosphorus determinations by the volumetric method described above, but in case of abnormal results, and occasionally in normal cases, checking the results by gravimetric determinations.

For sulphur determination, a volumetric (evolution) and a gravimetric method are also used side by side. The apparatus used for the evolution method is shown in Fig. 2, where four sets of this apparatus are shown in simultaneous use. It is found that one operator can work with four such sets without delay or inconvenience. The steel drillings are dissolved in the evolution flask of this apparatus in hydrochloric acid of 1.10 specific gravity, the operation being aided by heat, although boiling the acid is avoided.

The evolution flask and entire apparatus are filled, prior to the commencement of the operation, with an atmosphere of

was successfully overcome by suspending the galvanometer from a tripod in such a manner that the vibration is absorbed by three small spiral springs so arranged as to be in partial compression. The two recording instruments are regarded as the standard instrument of the department.

The following branches are wired up to and are under pyrometric control from the metallurgical laboratory: the heavy forges, the oil-hardening and tempering branches, the case-hardening shop, the drop-forging plant, the lead bath (specimen treatment plant), and the gas muffles throughout the department used by the tool-smiths and other craftsmen. Each of the larger sections has also an independent instrument room with a simple indicating instrument.

Both the indicating and recording types of pyrometer employed are made by James Pitkin & Co., of Clerkenwell, London. The temperature of boiling water is taken as a common zero for the temperature scale of the whole of the instruments comprising the installation. The standard instruments are calibrated by the arrest representing the boiling point of water as zero and the freezing points of "especially pure" tin (232° C.), lead (327°), zinc (419°), aluminium (657°), sodium sulphate (860°) and copper (1084°).

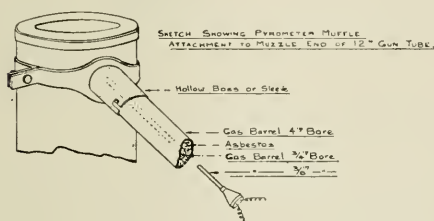


FIG. 3.—MUFFLE CONSTRUCTION FOR PYROMETER.

In order to insure that, as far as possible, the actual temperature of the article heated is ascertained as distinct from the temperature of the furnace itself, the pyrometer tube is sheathed in a circular muffle of non-conducting material in such a manner that the extreme end of the pyrometer, which is in close proximity to the couple itself, shall be in actual contact with the articles. The muffle ensures the absence of any false reading due to the temperature of the gaseous atmosphere of the furnace being conducted down to the thermo-couple.

The protecting muffles at present in use are of two distinct patterns. For use at the forge re-heating furnaces, the temperature of which approximates 1100° C. (2000° F.), these muffles are built up of hollow refractory fireclay cylinders or sleeves, similar to those used to protect the swan-neck stopper bar of the ordinary steel casting ladle. These cylinders are luted together and the whole heavily coated with refractory composition, which is then dried and baked.

At the furnaces of the oil-hardening section, there being no occasion for long-sustained high temperature, the protecting muffle is constructed from mild-steel tubing varying according to the size of the furnace from 3 to 6 inch bore, and having centering disks placed at regular intervals along the interior to admit of the insertion of an inner tube concentric with the outer one, and of sufficiently large bore to freely admit the insertion of the pyrometer. The annular space between the inner and outer tubes is tightly packed with well dried asbestos fiber. These muffles vary in length from 3 to 8 feet, as demanded by the nature of the work and the size of the furnace.

As many as five and six thermo-couples are sometimes inserted in the long vertical furnaces of the oil-hardening section employed in heating the larger forgings forming the inner tubes of the heavier guns. These gun tubes in the larger nature of ordnance sometimes exceed 60 feet in length. The furnaces are gas heated, and by means of air ports combustion may be

regulated with great uniformity especially when controlled by a number of thermo-junctions placed at regular ascending intervals in the walls of the furnace.

In this type of vertical furnace the muffles protecting the pyrometer are inserted horizontally through the walls of the furnace, and are of such a length as to extend from the walls to the side of the forging being heated. The muffle is supported at the furnace end in a hollow boss or sleeve clamped on to the forging (Fig. 3) in which the muffle tube fits by a rough layonet joint, the furnace wall forming the support for the muffle at the exposed end. The pyrometer is then inserted in the muffle, care being taken that the extreme end is brought into contact with the forging.

The top stages of the furnaces of the larger description are provided with a simple telephone in communication with the local pyrometer cabin, thus affording no excuse for the furnace-man leaving the stage when nearing the end of the finishing temperature.

As far as possible, the cold-junction of each couple with the pyrometer leads is maintained "at an equable temperature as nearly as possible approximating the normal atmospheric temperature," (a) by having sufficiently long pyrometers, the wires of the couple being threaded right through from the hot-junction to the head of the instrument, the latter being protected by asbestos screens wherever found necessary; (b) the further precaution is taken of calibrating the whole system with an allowance for the average cold-junction temperature of the various pyrometers in use throughout the system as ascertained by thermometric observations.

Some data are also given on the actual construction of the pyrometers in use.

The method used for the determination of the critical temperatures of any particular ordnance steel is that of plotting differential heating and cooling curves after the manner employed by Carpenter and Keeling at the National Physical Laboratory (*Journal of the Iron and Steel Institute*, 1904, No. 1, p. 224) and only differing from the method described by these two investigators in that no potentiometer is used, the readings being taken direct from an open scale.

Discussing Mr. Lambert's paper, Mr. Wrightson mentioned his experience with the Roberts-Austen pyrometer at the mint. He was of opinion that pressure on two opposing surfaces of iron brought about reduction of temperature, just as in the case of the re-gelation of ice.

Mr. Rosenhain objected to the method of measurement employed on account of the instability of the zero in the D'Arsonval galvanometer, and thought a bifilar galvanometer would obviate such tendency to error. He noted with pleasure the precautions taken to prevent action of furnace gases on the thermo-couple. The greatest care must be taken in this respect or results would not be reliable.

Mr. Gledhill said pyrometry was now a most important matter in connection with heavy steel forgings. The 12-in. gun forging required different temperatures according to the varying thicknesses at different parts. The old method of judging by the color was quite useless. The Siemens water pyrometer was useful in the hands of workmen as a check for the pyrometer. A record of treatment in manufacture was desirable.

Dr. Carl Benedicks asked if there were any special arrangements for regulating the temperature of the cold junction. He did not find any mention of this point in the paper.

Mr. W. H. Hadfield drew attention to the possible discrepancies arising from variations in construction of thermocouples. A couple in a silica tube indicated a temperature [fifty] 50° C. higher than when enclosed in an iron tube. This might be due to conduction.

Professor Turner insisted on the necessity for calibration under the exact conditions of use in every respect.

It was understood that the author's reply would be communicated later.

Cement from Blast-Furnace Slag.

A paper by Chevalier C. DE SCHWARZ (Liege, Belgium) deals with the utilization of blast-furnace slag. "Taking the total production at all blast-furnace plants in the world, according to recent statistics, at about 50,000,000 tons of blast-furnace slag for the last year, and assuming further that 1 ton of ungranulated blast-furnace slag measures, when broken up, about 20 cubic feet, the blast-furnace slag produced in one year represents a mountain of nearly 1,000,000,000 cubic feet."

In the first part of the paper the author reviews the development of processes for making brick from blast-furnace slag, while in the second part the manufacture of cement is discussed (which is far more profitable than brick making). The author does not agree with the statement which has been made repeatedly that no cement can be made from slag resulting from the manufacture of white pig iron.

"This is incorrect, as may be proved by the fact that Portland cement of good quality can be made from such slag, containing 42 per cent of lime and $4\frac{1}{2}$ per cent of oxide of manganese. The cement made from such slag showed not the slightest trace of instability of volume even after six years' use; it also stood all the tests required by the standards for Portland cement. The manganese oxide in the cement gave it a somewhat brownish color, which, however, was not considered a fault by some customers, but on the contrary was preferred to the ordinary tint for making artificial stones.

"To a certain extent the presence of metal oxides, such as those of iron and manganese, which, as a rule, are higher in slag from white pig iron, makes the cement made from it more apt to resist the influences of sea water. Secondly, the presence of metallic oxides reduces the temperature of fritting necessary for the formation of clinker, thus effecting saving in fuel as a

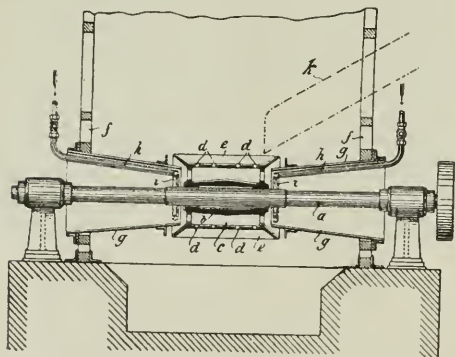


FIG. 4.—LONGITUDINAL SECTION OF COLISEUS APPARATUS.

consequence. A high percentage of lime in Portland cement is not only not necessary, but it is to a certain extent even injurious, as, being to a certain extent free, it causes the cement to 'blow.'

Of recent processes for making cement from blast-furnace slag, only the process of Colloseus has proven commercially successful. According to this process, solutions of alkaline salts are injected into the hot liquid slag and thus intimately mixed with the latter, the nature and concentration of the injected solutions depending on the chemical composition of the slag, principally on its contents of lime. The quantity of the solution to be injected should be as high as possible; however, the slag thus treated must be perfectly dry after the operation. The salts used for preparing the solutions are principally alum, sulphate of magnesia and nitrate of lime. The concentration, as a rule, varies from 2 to 5 per cent of salt to from 98 to 95 per cent of water.

On account of the great heat the salts are decomposed, most

of the sulphur escaping as sulphurous acid and sulphuretted hydrogen. The slag is chemically and physically changed, and gets the appearance of a porous clinker easily broken up and reduced to powder.

In case slag with a comparatively high percentage of silica and a lower percentage of lime is to be converted into cement, the concentration of the alkaline solution is raised to a maximum of 10 per cent of the salt to 90 per cent of water; besides this a small addition of common cement, clinker rich in lime, has been found beneficial in such cases.

Early difficulties with the apparatus employed have been overcome by the development of improved apparatus, shown in Fig. 4 in longitudinal section and in Fig. 5 in cross-section. The drum *b* fixed on the shaft *a* is divided into six interior

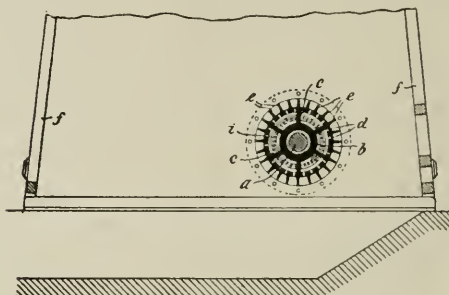


FIG. 5.—CROSS-SECTION OF COLISEUS APPARATUS.

partitions by means of cast-iron ribs *c*. On the outside the drum is provided with a number of other radial ribs *e*, running, like the former, parallel with the shaft *a*. Between the ribs *c* a number of longitudinal openings *d* are arranged to provide communication between the interior and the outside of the drum, the latter revolving at the rate of about 650 revolutions per minute. On this drum the hot liquid slag, coming from the blast-furnace, is led by means of a channel *k*, the whole apparatus being enclosed by a chamber or casing *f*, made of sheet iron and cooled with water from outside.

Two funnels *g* (Fig. 6) fixed on the casing *f* contain the tubes *h*, the latter leading the alkaline solutions to the revolving drums. At the same time through these funnels cool air is sucked into the interior of the drum along with the alkaline solutions and, the quick revolving drum acting like an exhauster, thrown out together through the openings *d* with a certain force.

In order to ensure a proper distribution for the entrance of the solutions into the interior of the tambour, two ring tubes *i* (Figs. 6 and 7) perforated with little holes (shown in Fig. 7) are provided.

The slag, being thus intimately mixed with the alkaline solution, is hurled with great force against the casing *f*, from where it falls by means of an incline into little bogies to be transported to the crushing-mills.

"From this description it may be seen that the working expenses for making cement from blast-furnace slag according to this process must be exceedingly low, and the initial outlay for erecting such cement works very moderate, as the drying and grinding of raw materials, as well as brick-making and the burning of clinker, is avoided.

"As to the quality of this cement, it may be said that, according to information received, it has stood all the tests prescribed for Portland cement by English, French and German authorities. The cement has been employed for about a year in the erection of viaducts, railway embankments, bridges, houses, etc., showing, up to date, not the slightest trace of damage."

The author finally describes the design of a ball-mill and air separator of German make for grinding blast-furnace cement.

In connection with Mr. F. E. Law's paper on the application of color photography to metallography, which was abstracted on page 206 of our last issue, it is interesting to note that the meeting had an opportunity to view the exhibition of lantern projections of colored photographs of Mr. Law. The great practical value of color-photographs was placed beyond question by the large number of splendid specimens shown, and Mr. Law was the recipient of well-deserved applause and hearty congratulations.

The president expressed the hope that Mr. Law would allow some of his beautiful colored photo-micrographs to be placed with the metallurgical exhibits in the Franco-British Exhibition.

The autumn meeting was then announced to take place at Middlesbrough in September next; and the proceedings terminated.

Recent Developments of Induction Furnaces.

A paper by J. HÄRDÉN presented before the Faraday Society on June 23, gives first some notes on the observation of the "pinch effect" in electric furnace practice. (See Carl Hering, this journal, Vol. V., p. 223.) "We have taken observations under working conditions in a 60-kw Kjellin furnace erected in London for experimental work. A small charge of pig-iron, consisting of about one-third of the full capacity of the furnace, was placed in the bath, and a current of 20 kw was employed. As soon as the charge was fully liquid the pinching effect commenced, and the metal was seen to contract at a certain spot, raising the level of the metal on both sides of the pinch, which was sufficient to break the circuit, causing a flash, immediately after which the metal flowed together again, closing the circuit. The level of metal immediately on each side of the pinched area rose about $1\frac{1}{2}$ in. above the normal level of the bath.

"It was found, on examination, that a small piece of slag was burnt into the bottom of the hearth at the point where this phenomenon occurred, thus causing the original reduction of area. Pieces of pig-iron were added to the bath, and as the depth increased the pinching slowly disappeared. It was found that if the original charge was about half of the full charge no pinching effect could be observed."

The author then discusses the "resistance curve of the melt"—that is to say, the curve obtained by taking the voltage across the terminals of the furnace during melting. Supposing we are starting the charge by means of a cold ring of welded or cast-iron. Putting on a full load and keeping the kilowatts constant, we first find that the voltage rises above the normal for full load, and as the ring gets hotter the voltage still gradually rises until the ring becomes a bright red heat.

From that point a decided drop in the voltage is noticed, although the power is kept constant and the weight of the charge is kept the same. As soon as the ring begins to melt the voltage again rises, but does not reach the same value as before the ring was red-hot.

Now let us consider the cause of this result. The furnace is nothing but a transformer, with a short-circuited secondary. This latter must be placed some distance from the primary, owing to the thickness of the lining, cooling chamber, etc. We therefore have a certain amount of magnetic leakage, not only around the primary, but also round the secondary. The secondary is of iron, with comparatively high permeability, and we have therefore introduced an easy path for the lines of the stray field, hence the increased inductive voltage across the terminals. This is to a certain extent compensated for by the lower ohmic resistance of the ring; but as the resistive coefficient of the latter is such as to increase with the temperature, the total resistance, measured across the terminals, will increase with the temperature, but the power factor will be lower during this period, which shows that it is not only the ohmic resistance that is increased but also the inductive resistance.

This is due to the fact that the permeability of the iron is also

increased to a certain extent with the temperature; in fact, it rises very rapidly up to a temperature of about 840° C., when the permeability begins to drop very quickly, and reaches zero at about 920° C. In this interval between 840° and 920° the inductive resistance is rapidly decreasing, because the easy path for the stray field is checked, and the voltage across the terminals is consequently lowered. But in the meantime the ohmic resistance is steadily increasing, but this rise is slower than the change in the permeability; therefore, the voltage will rise again, though slowly until the temperature is reached at which the loss by radiation and the heat introduced balance each other.

It may even increase somewhat above this point, owing to oxidation of the charge, but this increase is very slight. This is the reason why some people were misled into believing that the increase of resistance in iron due to heat was not a straight line curve. (It may, perhaps, not be so, but the effect shown on the furnace terminals is certainly produced in the way stated—which can be proved by the wattmeter readings.)

The chief part of Mr. Hårdén's paper deals with the Roehling-Rodenhauser modification of induction furnace which has already been described in detail in our January issue (page 10). In the original Kjellin furnace some disadvantages are experienced when dealing with material which has to be refined and treated in very large quantities. For instance, when a charge of three tons or more is to be treated, the section of the bath becomes very large, thus causing a low resistance, whereby the power factor is lowered. If we try to increase the resistance by making the ring wider in diameter and of smaller section, the distance from the primary will be greater and the power factor again lower. Thus it becomes necessary to employ a generator of very low periodicity for such furnaces, which is, of course, undesirable.

Also the processes of desulphurization and dephosphorization are very tedious, as it is difficult to keep the slag sufficiently liquid for such purposes. Nevertheless, this class of furnace will still hold its own, as it forms an almost ideal crucible steel furnace. In this case of crucible steel we have seldom to deal with more than one and a half to two tons at a time, and as it does not pay to use impure raw material, no refining is required, but plain melting and "killing", and for this class of work plain induction furnaces can be provided, which will answer very well at 15 to 25 cycles per second.

But when it is desired to refine say, a material smelted from inferior ores and decarburized in a converter, but still containing up to 0.1 to 0.2 per cent sulphur and 0.05 or more phosphorus, in quantities of five to seven tons, this plain induction furnace would not be so satisfactory.

The author states that about one-half of the power is transmitted to the charge by induction in the rings and the rest of the power through the side plates (which he does not like to be called electrodes in the old sense of the word). As the copper secondary is placed very close to the primary, the leakage field is very much smaller; in fact, three furnaces for one to one and a half tons are now in operation with 50 periods at a lower factor of 0.7 to 0.85, a result which could never be obtained with a plain induction furnace of a similar size, in spite of "bifilar" baths and other devices which have been tried.

"But this is not the chief advantage, as the same result may be obtained by other electrical means. A far more important gain is to be found in the metallurgical possibilities obtained with the new design. We know that for carrying out any refining process in steel we need a sufficiently liquid slag and ways and means of handling the same. This is to a certain extent obtained in some "electrode furnaces," where an arc plays between carbon blocks and the slag "blanket." This, however, in some cases, has proved troublesome, the drawback being that the temperature must be extremely and unnecessarily high at the spot where the arcs are playing, which is not without certain disadvantages to some steels.

"If we try to dip the carbons direct into the molten metal, we

find that they are consumed at once, in such cases contaminating the steel, which is, of course, difficult to avoid. But this is not so in the case of the combined furnace. The conducting side plates before mentioned are of quite a neutral nature; in fact, some plates which had been in constant use, day and night, for three months were so little corroded at the end of that period that the loss of the plates, calculated per ton of steel, was hardly determinable. Part of the power is induced in the rings, thus heating the charge, and the rest passes through the side plates, to such an extent only as experience has proved to be necessary in order to obtain a sufficiently liquid slag.

"The ring-shaped part of the bath is covered with bricks, at a height below the level of the charge in the center injurious to the lining, the rings need hardly any repair during a long run, whereas the rectangular bath in the middle is easily accessible, and can easily be patched out. The lining is simply burnt magnesite or dolomite, mixed with tar, and stamped in hot."

The progress of the operation is described by Mr. Hårdén as follows: After the lining is stamped in, the tar is burnt out (either by heating a cast steel ring or pouring a small quantity of pig iron into the hearth), leaving behind a sintered mass, forming a solid brick or basic lining. The pig-iron is teemed for treatment in the Ressemer converter, and a fresh charge is given, which is tapped direct from the converter. It is more economical to burn out the carbon and the silicon in the converter, before refining from phosphorus and sulphur.

The larger furnace at Völklingen will take a charge of four tons. Calcined lime is added to form a suitable slag; this slag also contains about 6 per cent of magnesia. Sometimes a small quantity of fluorspar is also added, to act as a flux, but this is not always necessary. Plate scale from the rolling-mill is added for decarburizing. In this condition the slag will take up the phosphorus very readily, after which it is made more viscous by applying cold lime and drawn off through the slag door by a slight tilting of the furnace.

It is essential for a successful dephosphorization that the charge should be what is called "hot brittle," i. e., have an excess of oxygen, in order to prevent the phosphorus wandering back into the charge again. After removing the slag which contains phosphorus, ferrosilicon or carbon is added, forming Si O_2 or CO , thus depriving the charge of the oxygen. It has been found that the adding of ferrosilicon will shorten the time of the de-oxidation; thus, if power is cheap, the cheaper carbon may be employed, and in the case of dearer power it is better to use the ferrosilicon.

As soon as the dephosphorizing is effected this first slag is entirely removed, and a fresh slag of lime only is formed, which, when the temperature is raised, acts as a desulphurizer in forming iron sulphide. The oxygen is also driven out in this operation, partly by forming calcium carbide, and partly by adding a small quantity of ferrosilicon and eventually some mill scale. After this, the maximum power is given, in order to drive out the last trace of oxygen, and as soon as no more gas bubbles are seen to leave the charge a test piece is taken out and forged. If too soft for the purpose, some coke powder is thrown in until the right proportions are arrived at.

As a rule the charge is finished in one and a quarter to two hours, but if necessary the steel can, without disadvantage, be kept in the furnace for ten hours or more. It is thus possible to treat a material which contains up to 0.1 per cent phosphorus and 0.1 per cent sulphur or more so that a product containing 0.006 per cent phosphorus and 0.02 per cent sulphur and from 0.5 to 0.1 per cent magnesia and 0.01 silicon will be obtained.

"As to the power consumption, if the furnace is charged with molten material from the converter, the consumption is from 125 to 150 kw-hours per ton of finished material. This, of course, depends upon the quality of the raw material, but 130 kw-hours may be taken as a good average."

The Roebbling-Rodenhauser furnace has been employed for the manufacture of rails and it is stated that they command from 258. to 458. per ton more than ordinary rails, owing to

their greater durability. Two analyses are given as follows: 0.075 C., 0.03 P., 0.594 Mn, 0.069 S; breaking strength 64 tons per square cm., elongation 21 per cent, contraction 28.5 per cent; the other steel contained 0.086 C, 0.018 P, 0.310 Mn, 0.077 S.

Finally a list is given of Kjellin, Roebbling, Colby, Heroult and Frick furnaces, in construction, in operation or not in operation. Besides three Kjellin and two Colby induction furnaces, it is stated that there are 15 Roebbling-Rodenhauser furnaces (7 in course of construction and 6 working and 2 not working) with a total capacity of 848,400 kg. (An account of the discussion which followed the paper will be found in the monthly letter from our London correspondent elsewhere in this issue.)

Evaporating by Means of Steam.

By OSKAR NAGEL, PH. D.

Steam is used for evaporation either directly by passing it through the liquid to be evaporated or indirectly by embedding steam pipes within the liquid.

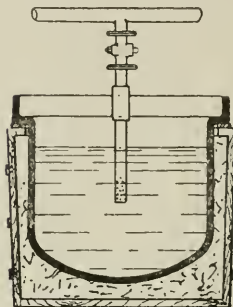


FIG. 1.—STONWARE EVAPORATOR.

If the nature of the liquid prevents the use of metallic vessels, stoneware vessels are generally used with direct steam. Fig. 1 shows such an arrangement in which the stoneware vessel is placed within another vessel and the space between the two is filled with a non-conductor of heat, like cement.

If the liquid is heated by means of steam coils, the latter may be of various shape, size and material. Spiral pipes are most generally used. Care has

to be taken that a moderate inclination prevails throughout, so that the condensed water can run off freely.

To prevent losses of steam and in order to be able to work under pressure it is absolutely necessary to connect the end of the heating coil with a condenser, which naturally has to be watched to prevent the coil from being filled with water.

Steam coils are used for evaporation either in open or closed vessels, depending upon the nature of the liquid and of the vapors formed.

Among closed vessels heated with steam coils we mention stills, extraction apparatus and vacuum-evaporators. Sometimes steam jackets or a combination of steam jackets with steam coils are used in place of coils.

The shape of these vacuum apparatus differs considerably. They may be spheroidal, cylindrical or of egg shape. The most suitable form depends on the "foaming" of the liquids during evaporation. Before the vapors leave the apparatus, they must generally pass through a trap provided at the top for catching and retaining any liquid particles. The apparatus is also

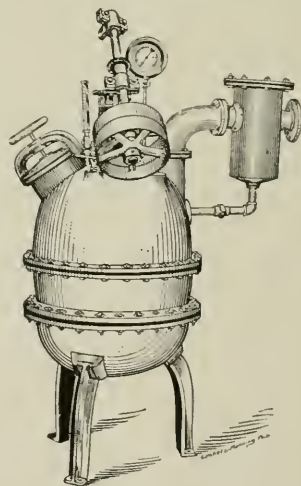


FIG. 2.—VACUUM EVAPORATOR.

equipped with a discharge opening at the bottom, a thermometer, a vacuum gauge, test cocks, steam, water and liquor valves, etc.

Fig. 2 shows an ordinary type of this apparatus made by Stuart & Peterson. It is preferably made of hard lead for acid solutions. Fig. 3 shows such an apparatus built up of three parts, each of one single piece.

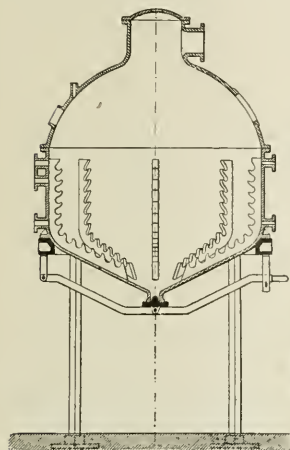


FIG. 3.—EVAPORATOR MADE OF THREE PARTS.

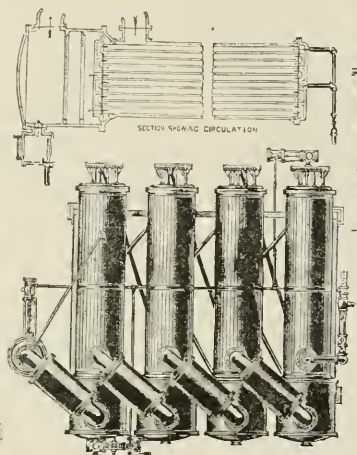


FIG. 5.—YARYAN EVAPORATOR. QUADRUPE EFFECT.

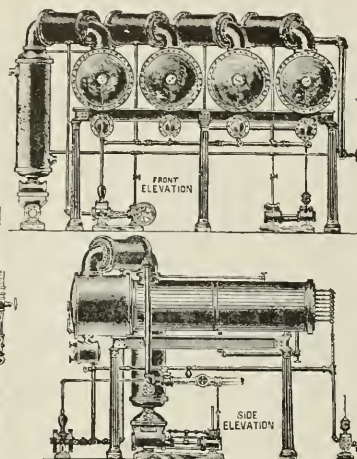


FIG. 6.—ORDWAY EVAPORATOR.

Formerly steam for the steam coils was directly taken from the boiler, but at present exhaust steam is also used for this purpose. This, however, necessitates a considerable increase of the heating area.

A large heating area, however, cannot always be provided by coils. Special tubular heating structure are, therefore, frequently used, as in the various evaporators to be described below.

The steam has to enter into the vessel as near to the top as possible, while the outlet for the condensed water is provided at the bottom of the vessel. If the steam for heating is to be used at a lower pressure than the boiler steam, a suitable valve for reducing the pressure must be employed.

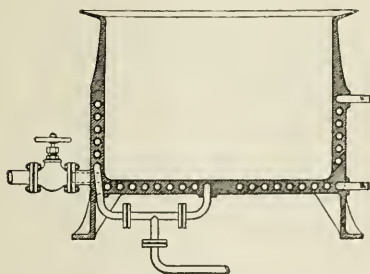


FIG. 4.—STEAM-JACKETED EVAPORATOR.

In stoneware vessels that part which is hit by the entering steam is preferably protected by a shield of sheet metal.

While in metallic vessels joints between different parts are often made by screws, different parts of stoneware vessels are preferably joined by means of Portland cement.

For substances which have a boiling point of over 200° superheated steam has to be used, and in such cases the evaporator

shown in Fig. 4 is successfully employed. In this case the coils are cast into the wall of the vessels, which may also be provided with a stirrer.

According to Dr. H. Claassen the main features of modern methods of evaporation are the use of a high vacuum and the principle of multiple-effect evaporation. The steam evolved in evaporation may be led into another set of steam coils and used

again for evaporation. Two apparatus coupled together represent a double-effect evaporator; three a triple-effect evaporator, etc.

We will now describe the most important types of evaporators used in the chemical industries.

In the Yaryan evaporator (Fig. 5) the material is kept in very rapid motion so as to be in contact with the heated surface only for a moment. The liquid to be concentrated is fed into one end of 3-in. tube coil, 50 ft. in length; and the rate of feed-

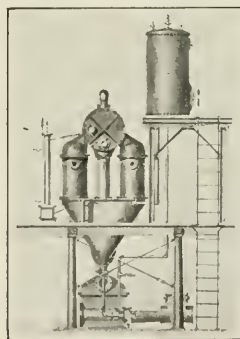


FIG. 6.—ORDWAY EVAPORATOR.

ing is so adjusted that the given heating surface will concentrate the liquid to the desired density. Only in extreme cases is it necessary to return the concentrated liquid for re-evaporation.

Exhaust steam can be used in this system without difficulty. For liquids that require a high temperature for evaporation Yaryans are built that can be used under 100-lb. pressure with perfect safety.

In the operation of this apparatus the steam is led into the cylindrical chamber surrounding the coils in the first effect. The liquid to be concentrated is fed into the first tube of the return bend coils of the first effect in a small but continuous stream, and immediately begins to boil violently. It becomes a mass of spray, containing, as it rushes along the heated tube, a constantly increasing proportion of steam.

The inlet end of the coil being closed to the atmosphere, and

tire series, whether a triple, quadruple, etc., effect is used, the volume of the liquid being constantly reduced in each effect.

The steam from the final effect goes to the condenser and the vacuum pump, a high vacuum being thereby maintained in the separating chamber and consequently in the coils. Hence the boiling point of the liquid is at a lower temperature than that of the surrounding steam, and by the condensation of the steam from the previous effect upon the cooler pipes in the next effect a less perfect vacuum is maintained in the preceding effect.

Thus we have in the series of effects a gradual reduction in

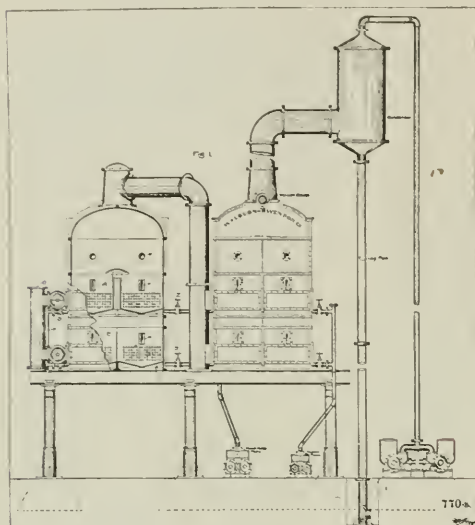
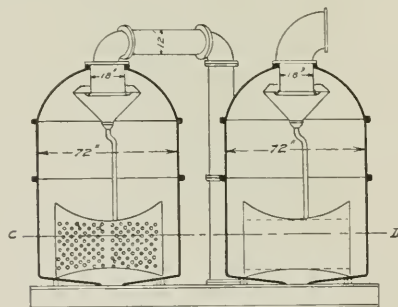


FIG. 7.—SWENSON EVAPATOR.

the steam being continually formed, the contents are propelled through the tubes at a high velocity, finally escaping from the last tube of the coil into the separator.

Here the steam or vapor, with its entrained liquid, which has been reduced in volume by the evaporation, is discharged with considerable force against baffle plates which separate the liquid from the steam, causing the former to fall to the bottom and permitting the latter to pass off through an ingeniously con-



Section A-B

FIG. 8.—ZAREMBA EVAPORATOR. VERTICAL CROSS-SECTION. DOUBLE EFFECT.

trived catch-all, which effectually removes any remaining liquid, into the chamber surrounding the tubes in the second effect, where its heat is utilized for further evaporation of the liquid.

The liquid from the bottom of the separator of the first effect passes into the coils of the second effect and in it the same process takes place as in the first effect, and so on through the en-

pressure and in boiling temperature, and this automatically adjusts itself, whatever the number of effects, so that the liquid is brought to the boiling point by the steam produced by its own evaporation in the preceding effect. Since a complete condensation of the vapor surrounding the coils in each effect takes place, and the boiling point of the liquid within the coils is below the temperature of the vapor outside, not only sensible heat available on account of the temperature difference outside and inside, but also the latent heat of the condensing vapor is absorbed by the liquid and used for evaporation.

The design of the Ordway concentrator and separator is based on the principle that a liquid concentrated to the crystallizing

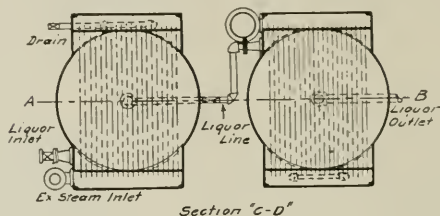


FIG. 9.—ZAREMBA EVAPORATOR. HORIZONTAL CROSS-SECTION. DOUBLE EFFECT.

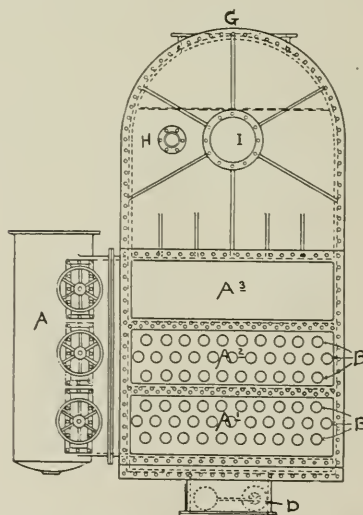


FIG. 10.—NEWHALL EVAPORATOR.

point will, if cooled, precipitate more rapidly and give a more complete separation. While the liquid is being concentrated it comes in contact with heating and cooling surfaces alternately, and in its passage from a cooling surface to a heating surface it passes through a precipitating chamber, where there is sufficient space to collect the crystals for removal.

Should the original liquid be sufficiently cool, it is used as the cooling medium before being fed into the evaporator.

The crystals are continuously removed from the precipitating chamber to a draining tank, which is under the same vacuum as the evaporator, and the drained liquid continually returns by gravity to the evaporator for re-evaporation. When the drain tank is filled with the crystals the circulation is stopped, or changed over to a second draining tank, and the crystals are removed from the first tank in a comparatively dry state.

The Ordway concentrator (Fig. 6) is made up in sections,

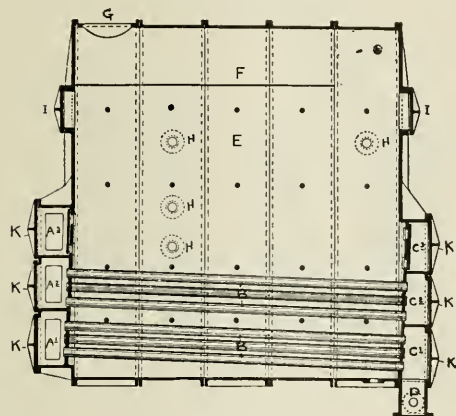


FIG. 11.—NEWHALL EVAPORATOR.

the different sections having the same proportion of heating surface to cooling surface and of vapor chamber to precipitating chamber.

These sections are flanged in such a manner that they may be bolted together to make up one evaporator effect of any size or capacity required, and when an increase of capacity is desired, all that is necessary is to add one or more sections to each effect, thus avoiding the necessity of installing a new plant.

The Ordway is built for single or multiple effect, and is provided with all the convenient appliances of an evaporating plant, such as eye-glasses in each effect, for observing the action of the

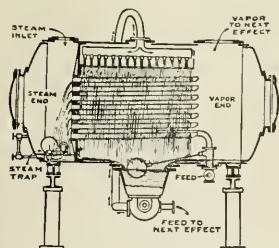


FIG. 12.—LILLIE EVAPORATOR.

liquid while boiling, a tester for testing the density of the liquid, water gauge, automatic feed regulator, condenser, pumps and all intermediate piping.

The submerged tube type of evaporator is represented by (1) the so-called Standard evaporators, consisting of vertically cylindrical shells fitted with vertical tubes, the steam being supplied to the outside of the tubes and by (2) the horizontal tube apparatus which carries the steam inside the tubes submerged in the boiling liquor. A well-known type of the latter is the old Swenson evaporator (Fig. 7) which shows a small double effect on this system. The shell is of heavy cast-iron

plates; tubes of seamless copper or steel, inserted in place by the use of elastic gaskets and packing plates, making possible their ready removal.

The advantages of this type consist of the shallow heating surface, the large area provided for the liberation of the generated vapor, absence of expansion troubles at tube joints, ease of operation, and absolute control of liquor density. When desired the steam chests can be so arranged that any desired percentage of increase of heating surface can be secured by merely adding the necessary tubes.

The latest development in multiple effect apparatus is the Zarembo round body evaporator shown in Figs. 8 and 9, which combines all the advantages of the Swenson heating surface with the structural advantages possessed by the shell of the Standard type. It will be noted that the joints are reduced to a minimum, internal braces are eliminated and that the pans can stand a considerable internal pressure without injury. Furthermore the down-takes are so designed that a much better circulation is obtained giving a heat transmission per square foot of heating surface over 20 per cent greater than is the case with the Swenson. In this connection, it should be borne in mind that the old style horizontal heating surface gives 30 per cent better transmission than the vertical tubes of the Standard evaporator.

The Newhall evaporator as built for chemical works, etc., is shown in Figs. 10 and 11. A is the steam trunk, from which the evaporator draws steam of desired pressure. A', A'', A''' are compartments from which the tubes are supplied with steam. B are the steam-heated tubes; C, the boxes for condensing water at the lower end of the apparatus; D, a float box with disk valve; E, the space for the vapor and boiling solution; F, a baffle float box with disk valve; G, and outlet; H, eight glasses to inspect the boiling conditions; I, manholes, and K, removable covers on the steam boxes.

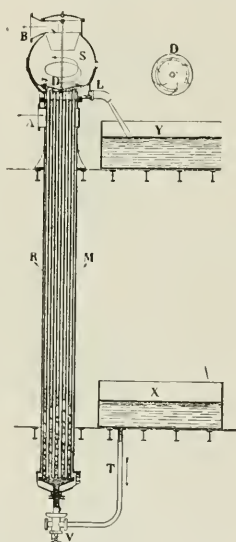


FIG. 13.—KESTNER EVAPORATOR.

A vertical longitudinal section through the body of a Lillie evaporator is shown in Fig. 12. The vapor ends of the tubes are closed. The condensed steam inside the tubes flows back into the "steam end" and thence through a steam trap usually into the steam end of the next coolest body.

The cut shows the circulation of the solution over the tubes as a heavy shower maintained by a centrifugal pump. The circulation is independent of temperature, and on the tubes there is no depth of solution through which vapors formed would have to force their escape.

The Kestner evaporator (Fig. 13) utilizes the principle of film evaporation in a simple manner. The design of this apparatus is such that the film is forced to cling to the heating surface independent of gravity, instead of being forced away from the hot surface by the steam disengaged. This means a very effective use of the heating surface and the possibility of concentration to the desired degree in one passage through the tubes.

In this "climbing film" evaporator the distribution of the film over the heating surface is made automatically by the disen-

gagement of the steam. The tubes in a Kestner evaporator are ordinarily vertical and are about 23 ft. long. The liquid is fed in at the bottom and the supply is so limited that the tubes are practically empty.

At the start the liquid begins to boil in the tubes and very shortly such a violent ebullition occurs that the vapor, occupying many times the volume of the liquid, rushes through the tube at such a velocity that it carries with it against the hot walls of the tube a thin film of liquid. This liquid film, together with the

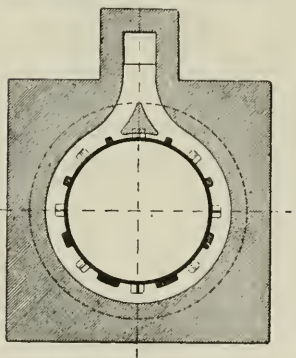
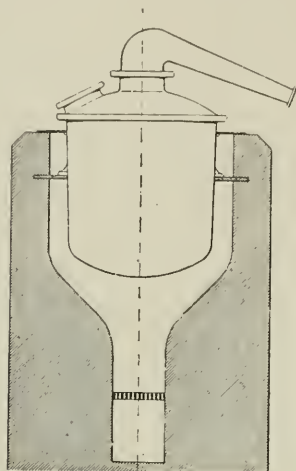


FIG. 14.—CAST-IRON STILL.

vapor, is discharged against suitably designed vanes of a centrifugal separator. In this way the concentrated liquid is whirled against the walls of the vapor belt and the vapor, thoroughly separated from the liquid, passes off to the next pan or to the condenser.

From this description it will be readily understood that the liquor is automatically elevated and evaporated in passing, the concentration depending on the amount of liquid admitted. This results in an evaporator essentially different in appearance from others.

* * *

A special case of evaporation is distillation for the purpose of separating liquids from each other. Every distilling apparatus consists, as a rule, of three parts: 1, the vessel containing the liquids to be separated; 2, the cooling apparatus, and 3, the vessel for receiving the distilled liquid.

The setting of a cast-iron still is shown in Fig. 14. Eight lugs cast into the shell of the kettle rest upon an iron ring in the brick work. Eight openings of various size are provided in the ring (those nearest the stack being the smallest), so that the fire gases are forced to play uniformly around the walls of the still. The fire gases pass through these openings to the stack.

On account of the low location of the grate, the flame does not come in contact with the vessel, whereby the life of the plant is considerably prolonged.

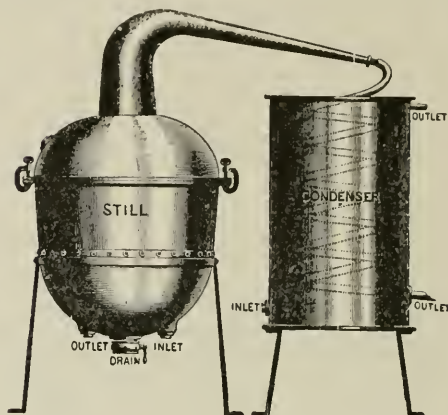


FIG. 15.—DISTILLING APPARATUS.

Many evaporators can be transformed in a simple way into distillation apparatus.

A distilling apparatus of the simplest construction is shown in Fig. 15. The still is heated by a coil; the substance distilling over is condensed in the condenser, which is cooled by water, etc.

A distilling apparatus for making sulphate of ammonia or concentrated ammonia solution from gas-water is shown in Fig. 16. In this apparatus, which was designed by J. L. C. Eckelt, in Berlin, steam jet blowers are used instead of coils, whereby a more thorough mixture of gas, water and milk of lime is ef-

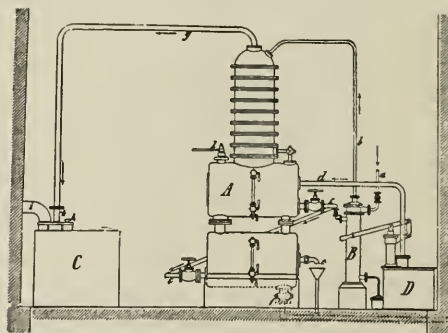


FIG. 16.—DISTILLING APPARATUS FOR SULPHATE OF AMMONIA.

fected, the capacity of the apparatus is increased and the steam is better utilized.

This apparatus consists of three parts, the lower boiler, the upper boiler and the tower on top of the latter. In the manufacture of sulphate of ammonia the ammonia liquor to be distilled flows through pipe *a* from a higher reservoir into the pre-heater *B* and then through *b* into the tower. The lower and upper boilers through valves *c*.

By means of a steam jet blower the gas-water is constantly kept in motion and thoroughly mixed with the milk of lime pumped in from the reservoir *D* through pipe *d*. The dissolved ammonia gas rises with the steam through the tower, while the water flowing the opposite way condenses the steam and liberates the ammonia.

The rising ammonia passes through pipe *g* into the saturating box *C* and is absorbed by the sulphuric acid contained therein. Foreign gases and vapors are carried by pipe *i* to a fire place or stack. Through valve *j* the lime mud is allowed to drop into the lower boiler, from time to time. Through cock *f* the mud is removed from the lower boiler.

The distilled gas liquor runs off through cock *e*. When the apparatus is stopped, the stopper *k* of the box *C* is removed to prevent the formation of a vacuum in pipe *g* by condensation of the ammonia gases.

For treating certain substances, distillation *in vacuo* is frequently applied. In this case the vessel which serves as receiver for the distilled substance is connected to a vacuum pump or to a steam jet blower.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

The Faraday Society.

At the annual general meeting on the 23d June, the officers and council were elected as follows:

President, Sir Oliver Lodge, F. R. S.; vice-presidents, G. T. Beilby, F. R. S., R. A. Hadfield, Geh. Reg.-Rat., Prof. W. Hittorf, Prof. A. K. Huntington, Lord Rayleigh, O. M., P. R. S., Prof. A. Schuster, F. R. S., Prof. J. J. Thomson, F. R. S.; treasurer, F. Mollwo Perkin, Ph. D.; council, Bertram Blount, F. I. C., A. C. Claudet, M. I. M. M., S. Z. de Ferranti, M. I. E. E., F. W. Harbord, F. I. C., R. S. Hutton, D. Sc., T. M. Lowry, D. Sc., H. F. K. Picard, M. I. M. M., James Swinburne, F. R. S., J. F. L. Vogel, M. I. E. E., and N. T. M. Wilmshire, D. Sc.

The discussion on Mr. J. HÄRDÉN's paper (published elsewhere in this issue) on Recent Improvements of the Kjellin and Roehling-Rodenhauser Electric Induction Furnaces was opened by Mr. F. W. Harbord, who was of opinion that the modified form of Kjellin furnace described by the author was an improvement of some value; but how a 7-ton furnace could compete with a modern converter with a capacity of 10 to 14 tons per hour or with a 50-ton open-hearth furnace was not apparent. In fact, the process was a method of refining, and should be employed in co-operation with a converter. This was the proper function of the electric furnace. The etched rail sections which were exhibited did not, in his opinion, prove much in favor of the uniformity of the electric product as compared with open-hearth steel. In all rails there was considerable variation in regard to uniformity. Was this steel actually being used for rails?

From materials as pure as those used in this process there was no difficulty in producing steel equally good in respect of high breaking stress and containing only a trace of phosphorus. He thought the main advantage consisted in its working in a non-oxidizing atmosphere. It was practically a crucible furnace for ton lots instead of pounds. The production of calcium carbide *in situ* was of great interest.

Dr. Harker said he hoped that the 25-kw experimental induction furnace at the National Physical Laboratory in London would soon be in working order. Various researches would then be carried out. Thus the increased resistance of iron at high temperatures would be investigated, and the physical constants of iron, steel and other metals at high temperatures determined. When high current densities were required through molten conductors the "pinch effect" caused serious trouble.

The advantage, for experimental purposes, of effecting the melting of metals and other substances in the inert atmosphere

of an induction furnace could hardly be over-rated. Makers of metallic-filament lamps wanted a furnace working *in vacuo*; and for tungsten, which combined with almost any gas brought into contact with it, such a furnace was necessary. He inquired whether the Colby furnace was in use for melting platinum and rare metals *in vacuo*.

Mr. E. Ristori considered that the title of the paper conveyed a wrong impression of the type of furnace described: for this was not purely an induction furnace but a combined induction and resistance apparatus. The inventors had to make use of the resistance principle because an induction furnace was inadequate and could not refine steel. He wished to be informed as to the extent to which refining had been carried out.

Dr. H. Borns asked the depth of the melted metal at the time the "pinch effect" occurred; and also the extent to which "centrifugal rise" is apparent with the Kjellin furnace. He believed that M. Héroult attached much importance to the formation of carbide in his furnace. Was there any true evidence of the production of carbide *in situ*?

Dr. R. Seligman inquired what were the current densities at which the "pinch effect" had occurred. Might not the "stickiness" of melted iron be something more than a mere matter of temperature?

The author, in the course of his reply, stated that the steel described was being used for automotors; and the Prussian State Railways have ordered considerable quantities for points and crossings, paying 50 marks per ton more than for ordinary metal. Calcium carbide was formed *in situ* in the slag, and acted as a sponge in drawing oxygen rapidly from the metal.

There was a good attendance at the ordinary meeting on the 10th June when Dr. FRANK read his paper on The Utilization of Atmospheric Nitrogen in the Production of Calcium Cyanamide, and Its Use in Agriculture and Chemistry.

The discussion was opened by Mr. H. Cottrell, who remarked on the difficulty of persuading the British farmer to adopt new manures; but the use of "nitrolim" was supposed by scientific agriculturists and those best acquainted with the values of manures. Artificial nitrogenous manures were alkaline and would cure the soil "sickness" caused by ordinary acid manures.

Mr. Walter Reid said he had found from experiment that the manurial value of nitrolim was dependent on the nature and condition of the soil. A clayish sand soil was too light; and moisture was necessary to the utilization of the new manures. He had made experiments on the use of calcium cyanamide in smokeless powders; and found that it distinctly reduced the flame and also lowered the temperature of the gases. Its use as a basis in the production of chemicals hitherto rare and costly should insure the gratitude of chemists to Dr. Frank.

Dr. H. Borns hoped that the author would be able to give further electrical details, viz., materials employed for the furnaces and electrodes, current used, and duration of heating the carbide with the nitrogen. He also made inquiries as to cost.

Dr. J. H. Voelcker defended the attitude of the British farmer in hesitating to adopt new materials before their cost and effect in comparison with the old had been definitely ascertained; and at present the cost of nitrolim to the farmer was unknown. Dr. Voelcker was understood to say that nitrolim could not be procured (commercially): its price was not quoted; and yet cost was the main question, for there was general agreement as to its results on crops. He did not admit that nitrolim was a more beneficial source of nitrogen than some other nitrogenous vehicles. Calcium cyanamide did not keep so well as ammonium sulphate; neither was the nitrogen it contained in such stable combination as that in sodium nitrate. In fact, it lost nitrogen. It was not convenient for mixing with some other fertilizers, e. g., superphosphates; because the admixture sometimes causes a considerable evolution of heat. In view of these difficulties, it was hardly fair to blame the long-suffering farmer for his conservatism.

Mr. H. L. F. Vogel inquired what would be the result if a charge of carbide were not completely acted on by the nitrogen.

Was not evolution of acetylene probable should the powder become moist? The cyanamide produced seemed to contain a very high percentage of lime. Could the author state the degree of purity of the nitrogen produced by the Linde process?

Mr. Leon Gaster asked what was the ratio of the cost of electrical energy to the total cost of production. In making comparisons with other systems it was essential to know this.

The chairman, Dr. F. Mollwede Perkin, mentioned the great utility of calcium cyanamide for the synthetic production of many important organic nitrogenous compounds, evidenced by the several samples on the table. As a basis for the chemical manufacture of such compounds the cyanamide opened out an entirely new direction, and he hoped that full advantage of it would be taken by chemists in this country.

The Aluminium Corporation, Ltd.

Speaking at the recent first annual meeting of the Aluminium Corporation, Ltd., Sir Jas. Sivewright said that in March the first furnace was tapped at Newcastle-on-Tyne, and they had been gradually adding to their furnaces there. The aluminium produced was of very high quality; fully 99 per cent pure. One carbon furnace was in full operation, and there would be three of them. In North Wales the works had been prosecuted with great vigor, and at the beginning of August they would be turning out aluminium at Dolgarrog to the extent of about 1500 tons per annum. When the company started aluminium was selling at from £180 to £200 per ton. The figures in the prospectus were based on aluminium selling at £120 per ton; but it was now about £80 per ton. Still, the directors viewed the situation with perfect equanimity, and he had no hesitation in saying that when their works in North Wales were in operation, and when their other works were completed, the Aluminium Corporation would be in a position, even with aluminium at its present price, to make good profits, and pay substantial dividends.

Royal Society's Conversazione.

At the May Conversazione of the Royal Society Mr. Cowper-Coles exhibited specimens of parabolic mirrors of the same size and shape as those used for searchlights in the Navy made by electro-deposition of silver on a mold made from a cast of an accurately parabolic glass mirror. They are said to give great penetration in foggy weather, and to show objects on which light from them is thrown in greater relief than does the light from an ordinary mirror, and are not so susceptible to breakage as are glass mirrors. One of the mirrors had several direct and ricochet bullet holes in it, but these had not materially detracted from its efficiency. Mr. Cowper-Coles also showed some sheets and tubes of pure electrolytic iron made direct from the pig-iron in one operation by a process of electro-deposition, and without rolling. The tensile strength of the iron is stated to be as high as 30 tons per square inch and it is free from crystalline structure. As far as could be observed, the sheets were of uniform thickness. The cost of power, with electricity at just over one farthing per unit, is about £2 10 0 per ton. Vessels spun from the sheets were also shown.

The National Physical Laboratory showed, among other instruments, a moving coil vibration galvanometer, belonging to a class of tuned galvanometers first introduced by Professor M. Wien. Its novelty consists in the use of the moving coil system. A small moving coil is suspended in the air gap of a strong magnet, and is strongly controlled by a bifilar suspension tightly stretched by a spring. By means of a milled head and screw the tension of the spring can be altered, and the frequency of free vibration of the coil varied between wide limits, bringing its period into tune with that of the source of alternating or pulsating current used, and the instrument will then be about 100 times more sensitive to currents of this resonance frequency than to those with frequencies much different. This instrument ignores the harmonics in an irregular wave form, and allows the measurements to be made on the assumption that a pure sine wave is being used.

Dr. T. E. Thorpe exhibited apparatus and materials used in the determination of the atomic weight of radium; also vessels of glass and quartz colored violet under the action of radium.

Messrs. Johnson, Matthey & Co. had a beautiful collection of laboratory apparatus of transparent fused silica; as well as an exhibit of vessels made of pure iridium.

Messrs. H. G. King and R. Kerr showed standard gages for extremely accurate measurements invented by Mr. C. E. Johansson, of Sweden, by using which, separately or combined, over 80,000 different sizes can be obtained, accurate to within 0.00004 in. at 66° Fahr. The steel is so treated as to minimize any change after hardening. The gages are used in the manufacture of machine parts, tools, and instruments, and for testing. The finish is remarkably fine. Two dry samples rubbed gently together adhere firmly under the pressure of the atmosphere.

A new extensometer shown by the Cambridge Scientific Instrument Co. is a practical instrument without delicate mechanism, made in two separate pieces, the lower one carrying a micrometer screw, and the upper piece holding the spring piece. Both pieces are attached to the test bar by pressing conical points of hard steel rods into center-punch marks in the side of the test bar, made in a special jig. These steel rods are clamped firmly in position, so that the two parts of the micrometer can rotate freely within backlash. A vertical arm forms part of the lower piece and has a knife edge at its upper end. In the upper piece there is a shallow notch which rests on the knife edge. Thus both the upper and lower pieces are held in definite positions. The relative movement of the lower piece carrying the micrometer screw and the tongue is measured, and is proportional to the extension of the test piece. The length of the test piece is 100 mm and readings can be taken to 0.0001 mm. Results can be relied upon to 0.00001 of the length of the test piece.

Market Prices for June.

Tin:—During June tin has shown on the whole a downward tendency since the 2d when it was £130 10 0. Total drop during month is from £130 10 0 to £126 10 0. From the 1st to 3d it rose from £128 to £130 10 0.

Copper:—Flatish. Highest price on 9th, 10th and 11th £58 10 0. Greatest variation for month from £57 15 0 to £58 10 0.

English Lead:—This has declined steadily, but recovered on 12th to £20 5 0, and has been steadily falling since. Total variation £1 0 0.

Hematite:—Fell from £61 on the 1st to £50 10 0 on the 2d and 3d, then steady till the 22d, falling to £58 17 6 on the 23d.

Cleveland Warrants:—Flatish with rising tendency from 4th to 15th. Total variation £1 5 0.

Scotch Pig:—Steady. Total variation 5s. Price on 23d £55 0 0.

Chemicals:—

	£	s	d
Ammonia sulphate, f.o.b. Liverpool.....	11	17	6
Copper sulphate	21	10	0
Caustic soda, 77 per cent.....	11	2	6
Bleaching powder, 35 per cent.....	4	5	0
Antimony regulus.....	£33	10	35
Shellac, standard T. N., orange spots, per cwt.	5	15	0
Carbolic acid, liquid, 97/99 per cent, per gal....		11	
Creosote, ordinary good, liquid, per gal.....		2	1/6
Naphtha solvent.....		2	6
Rubber, Para, fine, per lb.....		2	11

Rust Prevention.—A method of rust prevention, due to J. Corbett in Birmingham, consists in immersing the article in a hot solution of some phosphate and an iron compound. The metal surface becomes covered with a mixture of ferrous and ferric phosphates, giving a pleasing dull black appearance. The process is adapted for light engineering work, such as cycle frames, gun barrels, stampings and press work.

SYNOPSIS OF PERIODICAL LITERATURE.

Calcium Cyanamide.

Fixation of Atmospheric Nitrogen.—At the last Faraday Society meeting, Dr. Albert Frank, of Berlin, Germany, presented a paper on the utilization of atmospheric nitrogen in the production of calcium cyanamide and its use in agriculture and chemistry. The practical manufacture of calcium carbide in the electric furnace in 1894 by Willson and Moissan furnished Prof. Frank and Dr. Caro with the ideal base required for fixing atmospheric nitrogen in the place of the metallic base which they had previously used (barium) in their experimental search for a commercial method of producing cyanide of potassium for the recovery of gold in mining. As a result of these researches the Cyanid Gesellschaft was founded, which has supplied such a large proportion of the cyanides used in gold extraction in South Africa, Australia and the United States. They also led to the production of calcium cyanamide (nitrolim), a genuine substitute for sulphate of ammonia and nitrate of soda for all agricultural purposes, and which can be produced in unlimited quantities wherever limestone, coal and air are available, containing up to 28 per cent of nitrogen.

The only other practical method of fixing atmospheric nitrogen which has been perfected of recent years for similar uses to calcium cyanamide, is known as "lime saltpetre," and has been invented by Prof. Birkeland, of Christiania, but this process, though successful from the scientific point of view, requires considerably more expenditure of power than the Frank-Caro process, and the product possesses, for agricultural purposes, several drawbacks which calcium cyanamide does not. The latter has been so long and extensively tried by agricultural experts all over the world that its behavior is no longer doubtful. It can replace for all purposes sulphate of ammonia and for most purposes nitrate of soda, with the added advantage which neither of the others possesses of being alkaline instead of acid. It does not require any greater precautions in application than the other nitrogenous manures, and can with certain precautions become a useful constituent of mixed or complete manures, as has been determined by Dr. Hall's Rothamstead investigations. It is not so subject to being washed out of the upper soil by heavy rains as either of its predecessors and its effect is more persistent. The lecturer illustrated this part of his lecture with lantern slides of the relative results of the nitrogenous manures, including cyanamide, on a variety of crops—wheat, barley, oats, mangels, beets, etc., all showing at least equality with the older and better known manures.

Calcium cyanamide by melting with certain fluxes yields pure cyanide of potassium or sodium, and in the form of "surrogate," which can readily be produced near most gold mines, is an efficient substitute for cyanide in the recovery of the precious metals. Ammonia can also be readily and inexpensively obtained from it. Concentrated into dicyandiamide, it is in increasing demand for the manufacture of organic dyes, and its future as a "deterrent" in the form of salts of guanidine to reduce the temperature of explosion in high explosives and prolong commensurately the life of the inner tube of big guns, is assured; it also does away with the flash accompanying explosion, as well as with smoke. Mixed as a powder with other ingredients, calcium cyanamide tempers, hardens and cements steel in the most efficient way.

The author then proceeded to describe the practical features of the manufacture of nitrolim. The carbide is first ground to powder in air-tight mills, filled into furnaces which are kept full of nitrogen, and raised to and maintained at a temperature of 800° to 1000° C. for several hours, then allowed to cool slowly, and finally reground into a fine slate-black powder, which is sent out to the farmer in paper-lined bags, containing from 57 to 63 per cent of pure cyanamide or 20 to 22 per cent of nitrogen with about 20 per cent quicklime, 14 per cent of carbon, and 7 to 8 per cent of silic, iron oxide and alumina. To

replace the present consumption of Chili nitrate by calcium cyanamide would require something like 800,000 hp, and works are springing up all over the world to produce it wherever water power is abundant and cheap. The first works established for producing and selling 3000 to 4000 tons a year, working for the last three years, were in Italy, at Piano d'Orte (Abruzzi), and are now being enlarged for an output of 10,000 tons. Another works is just being erected at San Marcel (Val d'Aosta), for another 4000 tons, and the great Terni Carbide Works are laying themselves out for the production of some 10,000 tons in the near future. Dalmatia has followed the Italian example at Sebenico, at Fiume (each for an initial 4000 tons), and at Alhissa, where 50,000 hp are available, and a further 10,000 tons output is being planned, all the product being required in the Balkans, Hungary and the Mediterranean coast of Africa and Egypt.

France already possesses two works for an initial output of 4000 tons; Switzerland one for 3750 tons; Germany three works with an initial output of 12,500 tons; and one in prospect in the Bavarian Alps for 15,000 tons. The United States Cyanamide Company is erecting a 5000 to 6000 tons works at Ontario, in Canada, to begin with, and another to follow in Tennessee of much larger proportions. The central provinces of India are to be supplied from works on the Nerbuddha River, while the Japanese are erecting a works at the southern end of Kuisaku Island for an initial 4000 tons. The largest works, however, are due to British enterprise and have just been completed at Odda, in Norway, for an initial output of 12,500 tons with facilities for a prospective increase to 50,000. At the Odda Works the largest Linde plant for obtaining nitrogen from the air ever designed has been erected. These works are supplied with carbide from the adjacent works of the well-known Alby United Carbide Factories Company, with an initial capacity of 34,000 tons, which can be readily expanded to four times that amount by calling further on the available water power at command, up to 80,000 hp. Slides illustrating the features of the several works mentioned were thrown on to the screen.

The author concluded by stating that by the end of the present year works for the production of 45,000 tons of nitrolim would be in full swing, but this would not sensibly affect the market for sulphate ammonia and nitrate of soda, as the demand for nitrogenous manures and products was increasing so rapidly, by over 15,000 tons of nitrogen a year in Germany alone. Both agriculture and the arts and industries seemed capable of absorbing untold quantities of nitrogen in ever increasing amounts and there was no sign of surfeit. In any case, owing to the perfecting of the manufacture of calcium cyanamide, the possibility of Sir William Crooks' pessimistic forecast coming true had become very remote, and mankind was no longer threatened with a shortage in their bread. Diagrams were exhibited of the results obtained in comparative trials on various crops. In the discussion which followed the paper it was brought out that cyanamide is 10 per cent cheaper than ammonium sulphate. Its stability is good; although the lime absorbs moisture, there is no loss of nitrogen. Up to the present its manufacture in one operation (i. e., directly from the elements, without first producing calcium carbide) has not proved successful.

Gold and Silver.

Theoretical Considerations on Silver Ore Treatment with Cyanide.—In the journal of the Chemical, Metallurgical and Mining Society of South Africa, March, 1908, Mr. W. A. Caldecott discusses the reactions involved in the solution of silver from its ores, basing his views on a study of the properties of artificially prepared silver sulphide. The primary reaction, according to him, may be taken as the following: $\text{Ag}_2\text{S} + 4\text{NaCy} = 2\text{NaAgCy}_2 + \text{Na}_2\text{S}$. When a certain amount of silver has been dissolved according to this reaction, an equilibrium is established and solution ceases. It depends upon the amount of soluble sulphide in solution, how far the reaction proceeds before this equilibrium is reached, be this soluble sulphide derived

from silver or other sources. The amount of free cyanide present is also a determining factor. The author gives the following table of results obtained from a series of argentiferous sodium cyanide solutions, 50 cc of each having been titrated with 0.1 per cent sodium sulphide solution until a brownish color was just produced. A deduction of 0.35 cc is made to cover the amount of sodium sulphide which could be added without reacting with the silver present.

Per cent free cyanide (as K Cg)	Silver present mgrms per liter	Na ₂ S required mgrms per liter	Equiv. sol. Ag per cent (as Ag ₂ S) mgrms per liter
0.50	490	5.3	14.7
0.40	392	4.4	12.2
0.30	294	3.1	8.6
0.20	196	2.0	5.5
0.10	98	1.0	2.8
0.05	49	0.7	1.9

In this table the milligrams per liter may be read as grams per metric ton. It shows that the amount of silver capable of being dissolved as the soluble double alkali cyanide is approximately proportional to the amount of free cyanide present, but even with 0.5 per cent solution the quantity of dissolved silver is less than 0.5 oz. per 2000-lb. ton. Moreover, the introduction, through presence of free alkali or otherwise of soluble sulphide from any mineral or other source into an argentiferous cyanide solution will result in the precipitation of silver already dissolved. The author explains the fact that in practice many ounces per ton of silver existing as sulphide in the ore can be dissolved by the occurrence of secondary reactions, namely, the conversion of the soluble alkaline sulphide first formed into other compounds which do not preclude the further solution of silver. These secondary reactions are the following: (a) $2 \text{Na}_2 \text{S} + 2 \text{O}_2 = \text{Na}_2 \text{S}_2 \text{O}_3 + \text{Na}_2 \text{O}$; $\text{Na}_2 \text{S}_2 \text{O}_3 + \text{Na}_2 \text{O} + 2 \text{O}_2 = 2 \text{Na}_2 \text{SO}_4$. (b) $\text{Na}_2 \text{S} + \text{Na Cy} + \text{O} = \text{Na Cy S} + \text{Na}_2 \text{O}$. (c) $\text{Na}_2 \text{S} + \text{Pb O} = \text{Pb S} + \text{Na}_2 \text{O}$, $\text{Pb S} + \text{Na Cy} + \text{O} = \text{Na Cy S} + \text{Pb O}$. All these reactions involve absorption of oxygen, which appears to account for the utility of aeration. It appears from the first equation, mentioned in the beginning of the article, that the silver requires nearly its own weight of sodium cyanide to dissolve it and, therefore, the consumption of cyanide from this source alone would be nearly 1 lb. of sodium cyanide per ton. This fact would render the field for cyanide regeneration processes more promising than it has been in gold cyanide practice.

Laboratory Tests on the Use of Coarse and Fine Lime for Cyaniding.—With a view of ascertaining the relative rapidity with which commercial lime in varying states of division would be dissolved when distributed through a charge of inert sand and subjected to the action of percolating water, Dr. W. J. Sharwood instituted a series of laboratory experiments, the results of which are published in the April, 1908, issue of the journal of the Chemical, Metallurgical and Mining Society of South Africa. The proportions of water, sand and liquid were practically the same as those which prevail in the leaching of tailings at the cyanide plants of the Homestake mine, namely, an addition of about 3.5 lb. of lime per ton of sand, through which solution percolates at the rate of about one ton of solution in five days for each ton of sand. The conclusions from the results obtained by Dr. Sharwood confirm the experience obtained in Homestake practice, namely, that the most desirable condition is to have the lime largely in particles which are neither very coarse nor extremely fine. If much of it is in granules, that is, coarser than a 20 line mesh screen, these grains will remain partly undissolved at the end of the treatment. Previously-slaked lime and particles finer than 100 mesh yield about 95 per cent of their available alkali in five days' leaching, but they yield it at a rate which is not sufficiently uniform. Such highly comminuted lime gives too high an alkalinity to the cyanide solution at the earlier stages of leaching,

and this, with the pyritic ore in question, is detrimental to the solution of the gold, as it has been found that a protective alkali higher than 0.3 lb. per ton of solution gives decidedly low extractions. A further point in favor of granular lime is that the acidity of these tailings is distinctly cumulative, as there are 5 to 10 per cent of sulphide of iron present, a large proportion of which is pyrrhotite. The lime used in the Homestake plant is burned in continuous wood-fired kilns and is afterward crushed through a jaw crusher to about 1½-in. size. Sufficient is weighed out for a two-hours' supply, and this is dumped into the hopper of a Challenge feeder supplying the mortar of a one-stamp mill, having one screen, 11 in. x 14 in., and fed with a small stream of water. This carries the lime to a launder where it mixes with the previously classified tailings on their way to the distributor and leaching tank. A further addition of lime is made during the progress of leaching by spreading 200 lb. over the surface of each charge of 600 tons. However, if the alkalinity of the calmer effluents is unduly high in comparison with the percentage of cyanide, this top lime is omitted.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Vanadium.—F. M. Becket, 893,128, July 14, 1908. Appl. filed June 26, 1907. Assigned to Electro Metallurgical Co.

Vanadium sulphide ores are directly reduced in an electric furnace by means of calcium carbide or a mixture of calcium oxide and carbon. In the former case the reaction is $5 \text{V}_2 \text{S}_5 + \text{y Ca C}_2 = 5 \text{V} + \text{y Ca S}$.

Low-Carbon Ferroalloys.—F. M. Becket, 892,211, June 30, 1908. Appl. filed Jan. 8, 1908. Assigned to Electro Metallurgical Co.

Ferrotungsten and ferrovanadium are made in an electric furnace with iron electrodes which act as a supply of iron for the ferroalloys. The electrodes are cooled to regulate their consumption and the composition of the product.

Electric Furnace.—F. M. Becket, 892,212, June 30, 1908. Appl. filed Jan. 8, 1908. Assigned to Electro Metallurgical Co.

In order to reduce the radiation of heat from an open electric furnace, the operation is carried out in such a way that a solid crust is maintained on the surface of the fused charge. By properly proportioning the cross-section of the depending electrodes to the current employed, they are so heated as to prevent the crust from forming over the portions of the bath immediately adjacent the electrodes. In this way openings in the solid crust are provided which permit the charge to be supplied or stoked, and also provide for the escape of gases. The essential conditions of operation comprise an adjustment between the current density or heat development in the molten bath or slag and the composition or fusibility of the bath.

Low-Carbon Ferroalloys.—F. M. Becket, 891,898, June 30, 1908. Appl. filed Aug. 24, 1905. Assigned to Electro Metallurgical Co.

Low-carbon ferrochromium, etc., is produced by making first an alloy high in silicon and low in carbon and then eliminating the silicon by reacting upon further quantities of ore. The operation in case of ferrochromium is as follows: Chromite containing from 50 to 52 per cent $\text{Cr}_2 \text{O}_3$ and from 16 to 17 per cent of Fe O is mixed with sand, sufficient carbon to reduce not only the oxides of chromium and iron, but also a part or all of the silicious material, and a flux, such as lime, to form a suitable slag. This mixture is treated in an electric furnace, yielding an alloy containing 51.3 per cent chromium, 17.5 iron, 30 silicon and 1.2 carbon, if equal quantities of chromite, sand and coke have been used. This is the first step of the process. The second step consists in treating this alloy in another electric furnace with a mixture of chromite and a flux, such as lime. The silicon of the first alloy combines with the oxygen of the oxides in the chromite and forms silica, which passes into the

slag. If 6 lb. of chromite are employed for every pound of silicon in the alloy, the resulting alloy contains 70 per cent chromium, 28.9 iron, 1 carbon, and 0.1 silicon.

Calcium Carbide.—H. L. Hartenstein, 889,124, May 26, 1908. Appl. filed Feb. 13, 1907.

Lime is taken from the preheater or calcining furnace, while highly heated, and is mixed with a mixture of anthracite coal and coke or charcoal. The inventor prefers to employ anthracite coal screenings, which are in a more or less fine condition, and to 80 or 90 per cent of which he adds from 10 to 20 per cent of the coke or charcoal, which is also previously ground. By using anthracite coal and coke it is practicable to utilize the cheaper grades of coke, as breeze or refuse, which is higher in ash and impurities than lump-coke and contains much more than the anthracite coal. The use of anthracite coal alone would have objectionable features, such as excessive smoke, precluding a fair view of the electrodes when the furnace is opened for examination, and further it has a high resistance and consequently requires a higher voltage. These objections are sufficiently overcome by the addition of the coke or charcoal, but the results may be still further improved by the addition of a small portion (say, from 3 to 20 per cent) of bituminous coal, rich in tarry compounds, say, about 5 per cent. This is also employed in a state of fine subdivision.

Dark Coatings on Metals.—A. Classen, 801,982, June 30, 1908. Appl. filed Sept. 3, 1907.

The object is to produce a uniform metallic deposit of pure black or deep blue color. The process is particularly suited for depositing nickel, but may also be used for other metals. The articles is polished and the polish dulled by dipping into an acid bath or by means of a sand blast. The article is then electroplated with nickel in a solution producing white, shining nickel and containing, besides the ordinary salts, a decoction of licorice root or licorice root itself. The following composition of a bath is stated to give good results: 20 kg nickel sulphate, 4 kg sodium sulphate, 1 kg nickel chloride and 0.5 kg boric acid are dissolved in 100 liters of water and 5 kg extract of licorice root, or simply the root itself, is added to the solution. After a white, shining deposit is produced in this manner, the voltage is suddenly reduced considerably without removing the article from the bath. The desired dark color is thereby produced.

Plating Apparatus.—G. G. Backus, 889,744, June 2, 1908. Appl. filed Aug. 15, 1907. Assigned to Zucker, Levett & Loeb Co.

Mechanical details of construction of an automatic apparatus for electroplating articles in large quantities and in a continuous operation. A series of drums carrying the articles to be plated is moved along through the electrolytic tank while the drums are simultaneously rotated. A runway is provided for discharging the drums in succession as they arrive at the end of the tank.

Electroplating.—C. Glover, 892,417, July 7. Application filed Oct. 22, 1907.

Details of mechanical construction of a plating apparatus with a carrier adapted to move conveyors through the plating solution; these conveyers may be readily detached at will for the substitution of new articles to be plated.

Purifying Water and Sewage.—A. E. Woolf, 892,486, July 7, 1908. Appl. filed Jan. 11, 1908.

Sea water or an artificial 3-per cent sodium chloride solution is electrolyzed for the production of hypochlorite. This is used for sterilizing the water or sewage, which is simultaneously subjected to filtration. The third claim refers to "the process of treating liquid to effect sterilization, consisting in preliminarily effecting a partial sterilization passing the incompletely sterile liquid through a filter bed, maintained in operative sterile condition through the action of electrolytically produced disinfecting solution passing there through, and adding to the resultant effluent an excess of the disinfecting solution to effect complete sterilization."

Filtration of Atmospheric Nitrogen.—A. J. Petersson, 889,857, June 2, 1908. Appl. filed April 13, 1906.

The reaction chamber contains a central electrode and a ring-shaped or screw-shaped electrode surrounding the latter. The discharge takes place between the two electrodes radially while the air is moved in the direction of the axis. Excitation devices are provided around the reaction chamber for creating within the latter a magnetic field of axial direction. By this arrangement of the electrodes and the magnetic field in relation to each other, "it will be possible to obtain the power, by which the arc is displaced, proportional or approximately proportional to the length of the path that each part of the arc has to run, whereby the various points of the arc will be displaced at the same angular velocity, thus obviating the risk of the arc being disrupted." For creating the arc the inventor uses alternating current; for creating the magnetic field he uses either direct current or alternating current.

Concentrating Nitric Acid.—B. F. Halvorsen, 892,516, July 7, 1908. Appl. filed Feb. 9, 1906.

Electric discharges through air for the purpose of fixation of atmospheric nitrogen yield dilute nitrous gases. They may be absorbed by sulphurous acid, in which case nitroso sulphuric acid is obtained, or they may be directly absorbed by concentrated sulphuric acid in absorption towers. The object of this patent is to obtain concentrated nitric and concentrated sulphuric acid from such nitroso sulphuric acids or nitrosyl sulphuric acid. The nitrous acid or the nitroso sulphuric acid is dissolved in an excess of concentrated sulphuric acid. A small quantity of water is added, together with a suitable oxidizing agent, as MnO_2 , PbO_2 or chromic acid in such quantities as are necessary for oxidation. The nitric acid obtained is then distilled off in retorts of cast iron and the oxidizing substance is regained by electrolysis. Before the electrolytic process takes place the solution is diluted with water in sufficient quantity necessary for the electrolytic oxidation. The latter may, for example, be effected as follows: $Cr_2(SO_4)_3 + 6H_2O = 2CrO_3 + H_2SO_4 + 3H_2$. When the oxidizing substance has been recovered, a certain quantity of the sulphuric acid is taken away and the rest of the sulphuric acid, together with the oxidizing substance, is again utilized for the oxidation of another quantity of nitrous acid.

RECENT METALLURGICAL PATENTS.

Extraction of Copper from Oxide Ore.—W. A. Hendryx (889,129, May 26, 1908) patents a method of leaching copper from oxide ores in two steps. The ore, in a suitable state of subdivision, is thoroughly agitated in a solution of sodium chloride, calcium chloride or other saline solution capable of effecting at solution of the metal at a temperature which may vary from 120° Fahr. to the boiling point of the solution. By this treatment a substantial proportion of the metal contained in the ore, in the case of oxidized copper ores usually about 50 per cent, is brought into solution. The inventor then adds to the ore pulp, while still heated and without separating the saline solution therefrom, sulphuric acid, equivalent to the weight of metal remaining undissolved in the ore. The pulp is then subjected to heat and agitation for a further period of time until practically complete solution is effected. The metal-bearing solution is separated by discharging the pulp upon a sand filter and precipitating the copper by means of scrap iron in a rotary precipitating apparatus. The inventor has found in practice that a solution tank 17 ft. in diameter is capable of treating approximately 40 tons of ore at a charge and that 10 such charges may be treated in a day, the total capacity of each tank being, therefore, about 400 tons of ore in 24 hours. The essential economy of the method lies in the use of a relatively cheap saline solvent, such as sodium chloride or calcium chloride, to extract from the ore such proportion of the metal as can be rapidly dissolved by this solvent, acids being employed only to

complete the solution, and added only in quantity equivalent to the metal remaining in the ore after the saline treatment.

Amalgam for Mirrors.—J. Laval (892,435, July 7) patents an amalgam for coating glass in the production of mirrors. This amalgam is stated to be advantageous in its use when compared with chemical processes of silvering glass, in that it does not turn yellow or peel off if subjected to the action of the sun or heat, and will not tarnish or streak from dampness. The amalgam consists of 5 parts antimony, 20 lead, 20 tin and 15 mercury.

Fused Quartz.—In Lond. Elec. Eng'ing, of June 11, a process of Ludwig, Bolle & Co., for the electric fusing, refining and molding of quartz articles is described, being protected by British patent 5764 of 1907. "Silica is fused by heating it electrically in a horizontal or vertical carbon tube, which forms one electrode, in an electric furnace. The tube is surrounded by powdered carbon or other resistance material, and this is contained in a wide carbon tube, which forms a second electrode, the whole apparatus being cased in refractory bricks. One end of the inner carbon tube is closed by means of a movable carbon plug, the other by a plunger which can be lowered into the melted material. The silica may be compressed into the form of a solid block, or it can be pressed against the walls of a carbon tube so as to form a hollow cylinder, depending upon the shape of the plunger. The plunger may also be made hollow, and then steam or compressed air can be forced through it into the carbon tube. At the end of the operation the plug at the bottom of the tube may be removed, then the plunger can be employed to eject the silica."

Extraction of Gold.—To extract gold, platinum, silver from refractory ores, J. B. Alzugaray (892,110, June 30) treats the coarsely powdered ore by means of hydrogen fluoride produced by the decomposition of any fluorine compound by sulphuric acid. For this purpose the ore is mixed with fluorspar and a sulphate or sulphuric acid. The hydrogen fluoride which is evolved reacts on the ore and disintegrates it with the evolution of silicon fluoride, which can be recovered by passing the gaseous compound through a condenser in contact with water.

Galvanized Steel Poles.

An interesting novel departure in electric transmission line practice in the use of galvanized steel poles as manufactured by Milliken Brothers of New York City. The design of these poles has been completely standardized by this firm and special arrangements have been made in their bridge and structural shops for the manufacture of these poles.

The rolled steel shapes are carefully cut, punched and bent by special, automatic tools which insure the accuracy of each piece made. These special tools enable them not only to turn out a large quantity of material, but insure each piece being an exact duplicate, a matter that is very important in connection with work to be shipped in pieces. After the shop work is completely finished on the steel parts, they are taken to the galvanizing department, where they are galvanized by the hot process (except the bolts and nuts). This department is entirely new and specially designed and directed to do this particular kind of work.

The hot zinc bath which is used for the work is by far the largest bath of its kind ever constructed and is capable of taking in pieces somewhat over 30 ft. in length at one time, thus insuring a uniform deposit. The old-fashioned method was to use a very much shorter bath and dip the long members in one end at a time. This, of necessity, made a joint in the galvanizing, which is believed to be exceedingly detrimental. The bolts and nuts are galvanized by the electric process on account of the threads.

Standard specifications for galvanized steel poles, together

with interesting notes on tests, methods of shipment, etc., may be found in a pamphlet recently issued by Milliken Brothers and entitled *The Milliken Patent Galvanized Steel Poles*.

The Hancock Jig in a Triple Separation.

A recovery of 98 per cent of a waste material in making three useful products is the remarkable record of the Hancock Jig installed at the plant of the New Jersey Zinc Co. (of Pa.) at Hazard, Pa.

The Hazard plant is furnished with ore from the mines at Franklin Furnace, N. J. These ores are complicated in composition, containing several zinc ores, such as Franklinite, Willemite, Zincite, etc., aggregating about 26 per cent zinc oxide when the ore is concentrated.

The process of treatment consists of two parts, the oxide furnace treatment and the blast furnace treatment. In the former the concentrated ore is mixed with fine anthracite coal and charged into small furnaces, where the zinc is driven off as oxide—the zinc white of the metallic paint manufacturer.

The residue is a clinker containing the iron 38 per cent, manganese 11 per cent, and some unburned coal and zinc ore. This residue is passed over a screen and the coarse clinker treated in a blast furnace, producing spiegel iron. Since the starting of the plant the fine material from the screen has been waste. The fine coal and zinc was found to play havoc with the blast furnaces, eating out the linings and choking the throats with zinc oxide.

After years of operation the pile of waste became a mountain, and the management began to figure on its disposal.

After some experiments with Hartz Jigs and sizing processes, and with magnetic separation, the Hancock Jig was installed and proved a great success. It makes a triple separation, *i. e.*, zinc ore containing 16 to 18 per cent zinc oxide, for re-treatment in the oxide furnaces, iron manganese clinker, running 40 per cent iron and 14 per cent manganese for treatment in the blast furnaces, and unburned coal, running 65 per cent carbon, used in the oxide furnace charge. The only waste is 2 per cent ash, which is carried with the overflow water into a settling tank. The water is settled and pumped back into the jig, about 20 per cent being lost in each circulation.

The tonnage handled by the jig at this place is 15 tons per hour, or 360 tons per 24 hours, but it is capable of handling, if required, between 400 and 500 tons of material in 24 hours, which the jig handles easily. The feed is the regular run of fines from the furnaces heated after a cooling period of six hours.

This machine is the regular 25-ft. size Hancock Jig manufactured by the Allis-Chalmers Company, Milwaukee, Wis.

Notes.

Sifting and Mixing Machinery.—The Abbie Engineering Company, St. Paul Building, New York City, have opened a department, in charge of Mr. J. M. Charles, for the sale of silk and wire bolting cloth for use in pulverizing and fine grinding of chemicals, clays, colors and other materials.

Dr. Heraeus, the distinguished German chemist and metallurgist, has received from the Franklin Institute, of Philadelphia, the John Scott Legacy Premium and Medal for his improvements of the Heraeus-Le Chatelier pyrometer and the accuracy and interchangeability of the thermocouple which he has produced and which is known as the Heraeus element. Dr. Heraeus is represented in this country by his brother-in-law, Mr. Charles Engelhardt, Hudson Terminal Buildings, 30 Church Street, New York City.

The Moore Filter Company report that they have closed a contract with the Compania Beneficiadora de Metales, "La Union," S. A., for the erection of a type A Moore slime plant,

having a daily capacity of 150 tons dry slime, at the La Union mine of Pachuca, Mexico, of which Sr. Don Francisco Narvaez is manager. This type A plant was selected after careful investigation by Sr. Narvaez and on the recommendation of Mr. George Moore in preference to the type B, or stationary type, particularly.

The Laclede-Christy Clay Products Company, of St. Louis, Mo., announce the acquisition of the business, property and good will of the Jamieson-French Fire Clay Co., Lake Junction, St. Louis Co., Mo. Mr. Henry K. Lackland, formerly secretary and general manager of the latter company, will be associated with the Laclede-Christy Clay Products Co. in the capacity of manager of their high-grade clay department.

Messrs. Brown & Williams, patent attorneys, of 1550 Monadnock Building, Chicago, announce that Mr. Adolph A. Thomas has recently become associated as an assistant in their office. Mr. Thomas has for four years been an assistant examiner in the electrical division of the United States Patent Office. His time will be chiefly devoted to interference cases and patent applications involving chemical, electrochemical and alternating-current technique.

Messrs. Colne & Co., 11 Broadway, New York City, formerly Powell & Colne, contractors for the erection of Tropenas steel casting plants for over 10 years, have just completed an equipment at the Mare Island Navy Yard, California, which is now in successful operation, thus making 33 converters installed by them.

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

ELECTRIC FURNACES.—(Continued.)

No. 504,282, Aug. 29, 1893, Solomon Shaw, Milwaukee, Wis. Assigned to E. P. Allis Co.

Arc type. Shaft furnace for melting iron. The receiving chamber has a downwardly-converging bosh, connected by a narrow throat with a wide crucible below. Four horizontal radial carbon electrodes are arranged in passages opening into the throat. These electrodes are automatically fed by electromagnetic mechanism. Side flues may lead through the walls from the crucible to the upper chamber, supplying hot gases to preheat the iron. The crucible has a drop-bottom.

No. 504,308, Aug. 29, 1893, Solomon Shaw, Milwaukee, Wis. Assignor to E. P. Allis Co.

Arc type. Shaft furnace for melting iron and iron ore. The upper charge-receiving chamber and its crucible are connected by a narrow throat. The horizontal radial electrodes enter the lower end of the upper chamber. The crucible has two tap-holes at different heights.

No. 512,602, Jan. 9, 1894, Charles L. Coffin, Detroit, Mich.

Arc type. Forge for heating or working metal, comprising a refractory bed of calcined limestone, dolomite or marble and an upper block or blocks having openings receiving the metal and carbon electrodes. The electrodes are electromagnetically fed. An electromagnet beneath the bed deflects the arc. The bed contains a spiral of pipe by which hot air or gas may be fed through a nozzle into the heating zone.

No. 513,270, Jan. 23, 1894, A. F. W. Kreinsen, Mamburg, Germany.

Feeds the lower end of a rod electrode of metal to be melted against the lower end of a carbon rod electrode, the two electrodes converging downwards, or may feed the metal rod against the edge of a revolving carbon-disk electrode. The melted metal drops into a plumbago crucible heated to a temperature of 1600° to 2000° C. by a platinum resistance wire imbedded in its walls, or by a thin external sheath of platinum

acting as a resistor. The electrodes are inclosed by a hood covering the crucible.

No. 513,602, Jan. 30, 1894, Elihu Thomson, Lynn, Mass.

Resistance type. The resistor may be a carbon rod or plate or set of parallel rods or slabs; may be spiral or sinuous or crucible-shaped, or a loop, or a tube, or it may consist of a number of blocks or rings pressed together endwise. A spring may be used to force the terminals against the resistor. The resistor may be imbedded in powdered charcoal, in which a graphite crucible may be imbedded. The inclosure may be of carbon bricks set in carbon cement and may be traversed by tubes. The electric circuit may contain a fuse, which may be under tension, to prevent overheating. Its rupture may ring a bell. The conductors may be cooled by water circulation.

No. 530,919, Nov. 27, 1894, Charles L. Coffin, Detroit, Mich.

Arc type. Chamber of soapstone, slate, lava or iron, lined with slabs of carbon, lime or magnesia.

No. 530,479, Dec. 4, 1894, Geo. A. Goodson, Minneapolis, Minn.

Resistance type. Maintains temperature of molten type metal flowing through a tube to the mold by making the tube a resistor.

NEW BOOKS

SYNTHETIC INORGANIC CHEMISTRY. By Arthur A. Blanchard. A laboratory course illustrating the methods and principles involved in the preparation of typical inorganic substances, with study questions and supplementary experiments; arranged for first-year college students. 97 pages. Bound in cloth. Price, \$1 net. New York: John Wiley & Sons.

LABORATORY MANUAL OF QUALITATIVE ANALYSIS. By Wilhelm Segerblom. 148 pages. Price, \$1.25. New York: Longmans, Green & Co.

AN INTRODUCTORY COURSE OF QUANTITATIVE CHEMICAL ANALYSIS; WITH EXPLANATORY NOTES AND STOICHIOMETRIC PROBLEMS. By Paul H. Talbot. Fifth edition, revised and rewritten. 183 pages. Bound in cloth. Price, \$1.50 net. New York: Macmillan Co.

DETERMINATION OF RADICALS IN CARBON COMPOUNDS. By Hans Meyer. 232 pages. Bound in cloth. Price, \$1.25 net. New York: John Wiley & Sons.

LEAD AND ZINC IN THE UNITED STATES. By Walter Renton Ingalls. Bound in cloth. Price, \$4 net. New York: Hill Publishing Co.

AMERICAN IRON AND STEEL ASSOCIATION DIRECTORY TO THE IRON AND STEEL WORKS OF THE UNITED STATES. Seventeenth edition, corrected to March 1, 1908. 516 pages. Bound in cloth. Price, \$12.

ELECTRICITY IN MINING. By Sydney Ferris Walker. 505 pages; illustrated. Bound in cloth. Price, \$3.50. New York: D. Van Nostrand Co.

PRINCIPLES OF DIRECT-CURRENT ELECTRICAL ENGINEERING. By Jas. R. Barr. 59 pages; 294 illustrations. Bound in cloth. Price, \$3.25 net. New York: Macmillan Co.

DEVELOPMENT AND ELECTRICAL DISTRIBUTION OF WATER POWER. By Lamar Lyndon. 323 pages; figures, 80. Bound in cloth. Price, \$3 net. New York: John Wiley & Sons.

THE THEORY, DESIGN AND CONSTRUCTION OF INDUCTION COILS. By H. Armagnat. Translated and edited by Otis Allen Keyon. 222 pages. Bound in cloth. Price, \$2 net. New York: McGraw Publishing Co.

THE MATHEMATICAL THEORY OF ELECTRICITY AND MAGNETISM. By Ja. Hopwood Jeans. 544 pages; diagrams. Bound in cloth. Price, \$4.50. New York: G. P. Putnam's Sons.

"THE ELECTRICIAN," handy copper wire tables and formulæ; compiled by P. D. Brown. 34 pages. Bound in cloth. Price, \$1 net. New York: D. Van Nostrand Co.

AN INTRODUCTION TO ELECTRICITY: being a translation of the second edition of *Einführung in die Elektrizitätslehre*, with cor-

rections and additions by the author. By Bruno Kolbe. Translated by Jos. Skellon. 442 pages. Bound in cloth. Price, \$3 net.

THE GLASS-SAND INDUSTRY OF NEW JERSEY. By Barnard H. Kummel and R. B. Gage. 173 pages. Trenton, N. J.

MATHEMATICS OF MACHINE DESIGN, WITH SPECIAL REFERENCE TO SHAFTING AND EFFICIENCY OF HOISTING MACHINERY. By C. F. Blake. 35 pages; diagrams. Price, 25 cents. New York: Industrial Press.

BLANKING DIES. 49 pages, illustrations, diagrams, 80 (Machinery's reference ser.). Paper binding. Price, 25 cents. New York: Industrial Press.

THE PRINCIPLES OF MECHANICS: FOR STUDENTS OF PHYSICS AND ENGINEERING. By H. Crew. 305 pages. Bound in cloth. Price, \$1.50. New York: Longmans, Green & Co.

LOGARITHMIC AND OTHER TABLES FOR SCHOOLS. By Frank Castle. 36 pages. 20 cents net. New York: Macmillan Co.

A VEST-POCKET HANDBOOK OF MATHEMATICS FOR ENGINEERS. By L. A. Waterbury. 97 pages; illustrated. Price, \$1 net. New York: John Wiley & Sons.

BOOK REVIEWS.

NOTES ON HYDRO-ELECTRIC DEVELOPMENTS. By Preston Player. 73 pages, 3 illustrations. Price, \$1 net. New York: McGraw Publishing Company.

This little book is essentially one for the financier, treating the subject always from the side of the investor with just enough engineering to make clear the points taken. It will, however, be very useful to engineers who have reports to make on the development of water power. It carries the development through from the investigation of the site to the building up of the market for the energy.

The list of chapters will give an idea of the character of the book: Preliminary Determinations; Methods of Procedure; Engineering Examination; Extent of the Market for Energy; Cost of Energy Manufacture; Central Station Economics; Sale of Electrical Energy; Primary and Secondary Power; Capital Costs.

* * * *

THE THEORY, DESIGN AND CONSTRUCTION OF INDUCTION COILS. By H. Armagnat. Translated and edited by Otis Allen Kenyon. 212 pages, 100 illustrations. Price, \$2 net. New York: McGraw Publishing Co.

The field of application of the induction coil has greatly extended in the last few years and has created a demand for a theoretical treatment of the design which more nearly expresses the truth than has heretofore been the case.

Up to the present nearly all data which have been published on induction coils applied to special coils, and so little of the data required to render the results of universal application were given that they were of little use to designers.

To those who are interested in the theory, design or operation of induction coils (and there should be quite a number among electrochemists) we recommend this book, and can safely say it is the best of its kind that we have seen.

The abbreviated list of contents given below will give a good idea of the field covered by the book: History; Theory of Mechanical Interrupters; Theory of Electrolytic Interrupters; Secondary Current; Power and Efficiency; Construction of Induction Coils; Construction of Interrupters; Special Induction Apparatus; Uses of Induction Coils; Bibliography (1832 to 1908).

Mr. Kenyon has again carried out his task as translator and editor in a manner which deserves the highest recommendation.

* * * *

ELECTRICAL CONTRACTING: SHOP SYSTEM, ESTIMATING, WIRING CONSTRUCTION, METHODS, AND HINTS ON GETTING BUSINESS. By Louis J. Auerbacher. 161 pages, 225 illustrations. Price, \$2 net. New York: McGraw Publishing Co.

This is a book for contractors and wiremen, especially use

ful to the small contractor who is new in the work and needs to establish an efficient shop system and build up his business. The book gives a complete shop system; tells how to design and install wiring for arc and incandescent lamps, alternating and direct-current motors, alarms, telephones, gas-lighting systems, etc., and gives many hints which will enable the contractor to make good profit off a given job.

The abbreviated list of contents is as follows: Shop System for Electrical Contractors; Estimating on Contract Work; Wiring Systems; Exposed Circuit Wiring; Wiring with Wooden Moldings; Wiring with Flexible Conduit and Armored Cable; Wiring with Iron Conduit; Residence Wiring; Wiring for Direct-Current and Alternating-Current Motors; Installation and Operation of Direct-Current Generators and Switchboards; Electric Signals and Telephone Systems; Special Devices.

* * * *

UNIVERSAL CALCULATING CHART. By Thomas R. Taltavall. Chart, 24-ply cardboard (7 in. x 9 in.). Booklet of instructions. 34 pages, 15 illustrations. Price complete, \$1 net. New York: McGraw Publishing Co.

This device consists of a rectangular co-ordinate scale similar to ordinary cross-section paper, fitted with a transparent celluloid arm which is pivoted in the lower left-hand corner and carries a linear scale equal to the one on the chart. By placing the arm at any angle, the arm forms one side of the triangle, the other two sides of which may be read off on the co-ordinate scale. The upper horizontal and right vertical edges of the chart are provided with an angular scale, permitting the angle at which the arm is set to be read in degrees and minutes.

With this device in sine, cosine, tangent, cotangent, secant and cosecant can be read directly to three places. Trigonometric problems involving these functions can be solved directly without the use of the function. Multiplication and division are accomplished by utilizing the properties of similar triangles, the arm being set at the intersection of 10 with one of the numbers to be multiplied; then, at the intersection of the second number with the arm will be found the product of the two numbers.

It is believed, however, that this device will find its greatest field of usefulness in the solution of alternating-current problems, where vectors in quadrature are often encountered. By laying the resistance and reactance off as abscissa and alternates, respectively, and placing the arm at the intersection of the arm, the impedance, angular-phase displacement and power factor can be read off directly, and if it is desired to change from the impedance to the admittance triangle, this can be done with one setting of the arm, and the conductance and the susceptance determined.

* * * *

THERMOCHEMISTRY. By Julius Thomsen. Translated from the Danish by Katharine A. Burke, D. Sc. 510 pages, illustrated. Price \$2.50. (Textbooks of Physical Chemistry of Wm. Ramsay.) New York: Longmans, Green & Co.

Sir Wm. Ramsay, as editor of the Textbooks of Physical Chemistry, deserves the thanks of all students of physical chemistry for having made Thomsen's classical work on thermochemistry available to English readers.

The fourth edition of Thomsen's *Thermochemische Untersuchungen* appeared in 1886. The immense fundamental value of this work has always been fully recognized. It is a human document, summing up the results of a lifework, full of endeavor. All results are directly the outcome of Thomsen's own experimental work in thermochemistry. All have been found by his own methods, with the same apparatus and under the same external conditions. All are directly comparable.

The translation by Miss Burke is excellent, but the editing seems to have been slightly overdone. An attempt has been made to modernize certain statements. But hyper-modern readers will hardly be satisfied. And, on the other hand, Thomsen's work is a classic and should be treated as such. It is out of place to try and modernize a classic.

Electrochemical and Metallurgical Industry

VOL. VI.

NEW YORK, SEPTEMBER, 1908.

No. 9.

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH. D. *President*
E. F. ROEBER, PH. D. *Editor and Secretary*
C. E. WHITTLESEY. *Treasurer*

Yearly subscription price for United States, Mexico and United States dependencies, \$2.00; for all other countries, \$2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, SEPTEMBER, 1908.

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Electrochemical Processes for Equalizing the Central Station Load.

Niagara Falls and the French Alps are the two largest centers of electrochemical industries. Yet it would be wrong to conclude that cheap water power is necessary for the success of electrochemical work. The majority of the large electrolytic copper refineries of this country have been established near New York City and are operated by steam power. Other considerations, like freight and labor conditions, are important besides power. But it is true that power is one of the most important items on the cost sheet of any electrochemical process. It is natural that progressive central stations in their endeavor to find new customers, especially at times of weak load, are turning their attention to electrochemical industries. The easiest method of storing electrical energy is in form of chemical energy. The lead storage battery is the classical example. But every electrochemical product may be considered as a substance in which electrical energy is stored in form of chemical energy. To make electrochemical products is equivalent to the storage of energy. What the electrochemist needs is cheap power. Both sides must necessarily make concessions. The central station must be willing to make a low rate. The electrochemist must be willing to take the power only at certain hours of the day; that is, he must work intermittently. Is it possible for both sides to make such concessions?

* * *

If a central station can fill up the serious valleys of its load curve by electrochemical processes, its fixed charges and pay roll are not affected; it is essentially the fuel cost that increases. A low rate should not be out of place under such conditions. The electrochemist, like everybody else, desires to work continuously at full capacity. But there are electrochemical processes which can be worked with profit intermittently and there are others which must be worked in that manner (carborundum, graphite). Electrolytic processes are not easily adapted to such conditions. It is to electric-furnace processes that the central-station men should turn their attention. The subject has been ably discussed by C. J. Russell in a paper before the Association of the Edison Illuminating Companies in 1906 and in three American Electrochemical Society papers of E. A. Sperry and John Meyer (Transactions, vol. 9, 11, 13). A good commercial beginning has already been made by the Philadelphia Edison Company. Now the Brooklyn Edison Company is entering the same field, as is indicated by a recent conference to which officials of the Brooklyn Company had invited a number of Philadelphia Edison men and several electrochemists. It is still true, however, that both sides—central-station men and electrochemists—have not yet come to a sufficient understanding of their mutual needs. This can come only through discussion. We will gladly place our correspondence columns at the disposal of both sides, in the firm belief that when a

clear understanding is reached more tangible results will follow. Central-station men should make up their mind how low they can make their rate and for how many hours they can guarantee to supply power per day continuously. On the other hand, electrochemists and electrometallurgists should consider whether the evident advantages of a reasonably low power rate in a large city would not outweigh the disadvantages of intermittent working. It is clear that each case must be considered separately and must be decided on its own merits. For many electric-furnace processes, within a certain size, it should pay to look carefully into the possibilities of such an arrangement.

Remember the Reader.

Mr. T. A. Rickard, the distinguished and genial mining engineer and editor of the *Mining and Scientific Press*, has recently published a small book entitled "A Guide to Technical Writing." The numerous friends of the author or of his multifarious papers and books know that he has something to say on the proper use of the English language. It is hardly necessary for us to add that the author states his case well and in a pertinent and straightforward manner. We sincerely hope that his little book will provoke greater attention to the fundamentals of good technical writing and will prove a useful help to writers on mining, geological and metallurgical subjects. For it is to this class of technical writers that the special illustrations of the rules of the author will particularly appeal. We have emphasized before in these columns the importance to engineers not only of correct thinking, but of concise and clear expression of their thoughts in reports as well as in articles and papers. For the time will come when the powers of writing and speaking well and to the point will turn the balance betwixt mediocrity and eminence. If someone thinks he has something to say he should say it well, that means, in such a way that the reader will easily and concisely catch the meaning. "Remember the reader" is a leitmotiv that appears again and again and always forcefully in Mr. Rickard's essay. It is such a good general rule that it suggests a few words on some points not touched by Mr. Rickard.

* * *

The first point we wish to make relates to references to prior work. It seems that modern technical writers grow more and more careless in giving references, if they do not omit all references to prior work of others altogether. Two examples may illustrate this. A paper presented a few weeks ago before the Faraday Society in London on recent developments of the induction furnace, contains interesting observations on the "pinch effect." The lack of any reference, however, to prior investigations of this phenomenon seems a mistake. The average reader cannot be expected to know the work of C. Hering, P. Bary and E. F. Northrup. He will, therefore, not recognize that the results obtained by the present author with the induction furnace are an interesting confirmation of former researches. The average reader may also be misled to think that the pinch phenomenon is in some way peculiar to the induction furnace, while as a matter of fact under suitable conditions it will manifest itself in any liquid or gaseous electrical conductor. The phenomenon as described by the author is an interesting isolated fact, nothing more. If

he had added the references (a few lines would have been sufficient), the reader would have been able to see the value of these observations in their proper light and in their proper connection with other facts. To omit references to prior work is universally unfair. It is not fair to those who did the former work. It is not fair to the present author (because such an omission, while being simply the result of carelessness or laziness, may easily be misconstrued as being intentional). But above all, it is not fair to the reader. An author who has something to say on a subject may be expected to have all the references at his fingers' ends. To give them would be for him the work of a few minutes, while for somebody not acquainted with the subject it may mean a search of days or weeks.

* * *

In a recent article published in an American journal reference was made to a special steel patented by a well-known engineer "a few years ago." The reference seemed fairly good. It seemed an easy matter to find the patent. Our experience was as follows: In view of the nature of the steel it was expected that the patent had been granted after 1900. In looking through the yearly indexes of the Patent Office from 1900 to 1906 it was quickly found that the patent had not been granted during these years. From the reference, as given, it then did not seem impossible that the patent might have been applied for "a few years ago," but granted only recently. The patent office has not yet published the yearly index for 1907 and has only announced that the bimonthly indexes for 1907 will not be published at all (another of those truly remarkable changes of this institution). It thus became necessary to look through all the weekly gazettes, with the result that the patent was not found. It was finally discovered among the 1896 patents, but it was necessary to read the specifications of all the patents granted to the prolific inventor in question, since the title of the patent did not indicate anything of a special steel. This search took just five hours. Surely no author has the right to waste other people's time.

* * *

The other point on which we wish to say a few words is the use of formulas in technical literature. There are still a few "practical men" who confess openly that they will not read an article if it contains formulas or mathematics. There are still some more who think the same, but no longer say it. Nevertheless, the ridiculous and thoroughly unfounded dislike of formulas, which was formerly common among practical men, is rapidly disappearing. Metallurgy has changed with surprising rapidity from empiricism to applied science. A clerk in a business office who does not understand stenography is left in modern business life. A metallurgist who does not understand to interpret a chemical formula will also be left. It is necessary to recognize fully the wealth of information that can be obtained from a simple formula. It gives the relative weights of the substances involved in a process; if there are gases involved, the formula gives their volume; with the aid of thermochemical tables it gives the energy balance sheet of the process; if the process be electrolytic, the formula gives the relation between ampere-hours and weights, and so on. All this information is obtained from one and the same equation. Chemical formulas represent the most concise short-hand method imaginable. Moreover, they are understood

the world over. They are the natural esperanto of chemists and metallurgists. In the interest of the reader, chemical equations should not merely be tolerated in metallurgical literature; they should be the rule. While in chemical equations there is almost complete uniformity of notation all the world over, it is not so in other branches of engineering. But the recent activity of electrical engineers in their endeavor to establish uniformity indicates that its desirability is at least clearly recognized.

A Logical Guess as to Coal Mine Explosion

In the last two winter months of the year 1907 there occurred four bad and serious accidents in the Appalachian coal field. The loss of life and prosperity was appalling. Nearly a thousand lives were extinguished and many thousands of dollars of capital annihilated. Investigation of the causes by State and national authorities disclose officially the fact that the explosions were due to the ignition of gases or of coal dust. This was a plain statement which even an ordinary engineer knew all along. The deeper-seated or primary causes are now brought out clearly by Mr. Carl Scholz in a paper published in the July issue of the *Monthly Bulletin* of the American Institute of Mining Engineers. The analysis of the conditions discloses that the "hygrometric condition of the atmosphere has the greatest effect upon the cause of the explosions." For example, mines in a high dry altitude are especially dangerous. The colder and drier the weather, the greater is the liability to danger.

* * *

Of course, the higher the coal of a mine is in volatile matter, the greater the tendency to explosion, and this, independent of any climatic condition, is a determining factor. It was further brought out that with the advent of improved ventilating machinery the mine explosions began to happen and that in the old mines ventilated by furnaces the explosions were, practically speaking, unknown. A study of the conditions of mines in Oklahoma shows that in a certain mine in winter with a temperature outside of 32 deg. Fahr. and a humidity of 95 per cent, the relative humidity of the air forced into the mine, where it assumed a temperature of round 62 deg. Fahr., was only 33 per cent. There must always be a certain amount of coal dust in the entries of even the best-managed mines and this will, of course, be pretty well dried up by the incoming dry air. The explosive force of dry bituminous coal dust is well known and a painful remembrance is carried by us in the awful explosion of this dust in a large cement works near New York City. With this in a dry pulverulent condition it is axiomatic to say that it is little less dangerous than gun-powder. We believe that this all is sound reasoning and conservatively can be called a logical guess as to the cause of coal-mine explosions.

* * *

A corollary to this is that English mines are safer because of the damp English climate. The effect of the English dampness on other business is marked. And American textile manufacturers began to make an artificial English fog by spraying water into the air of their plants in order to moisten it. The natural practical outcome of this is that all coal mines situated in the dangerous zone should have their air artificially

moistened to keep the dust wet and so safe from explosion. This will have the effect further of preventing the stratification of "fire-damp" or methane in the mines. We have given this paper of Mr. Scholz prominence because it is our belief that science and technology should elevate life and eliminate its hardships and dangers. Mr. Scholz's paper is a conspicuous example of the practical effect of ability of modern applied science to attain this end.

The Psychological Moment to Get Ready for Prosperity.

During an industrial depression, such as the one from which the country is just emerging, business conditions are entirely different from conditions of business pressure. Instead of buying in normal amounts every concern and every person have a tendency to pursue a hand-to-mouth policy of purchases. Only when exceptional bargains are offered do large sales ensue and then only on the part of the wise and courageous. The policy of retrenchment is in the air and, by our common psychological atmosphere, infects everybody. A much more rigid scrutiny of wants and values is now made. Everybody is working more and spending less. But above all, the money that is being spent is spent more judiciously. In the period of working under maximum pressure there was no time to look after many details. Then every manufacturer was forced to get the most out of his organization as it existed. Now in these dull times long-delayed improvements and changes in plant, process and organization are being made. The country is again getting ready for prosperity. An outward indication is that advertisements in recognized mediums of publicity are increasing rather than decreasing. It is quite apparent that the shrewd business man is trying first of all to hold his share of his trade and next to prepare for his share of the enlarged future trade by judicious use of the columns of such technical journals as have a high-class clientèle. Both in quantity, quality and tone, advertisements must present the wares well and fully to this rigid scrutiny of the buying public. In these dull days the manufacturers are looking carefully into all possibilities of increasing efficiency and reducing wastes by adopting methods and devices which were formerly considered interesting, but now become of actual importance. The country is getting ready to buy as well as to sell.

* * *

History of the past depressions proves conclusively that sound concerns which have taken advantage of slack times to effect improvements in process, plant, distributing and advertising departments, have reaped a harvest when the pendulum swings the other way. People with the right stuff in them are not now bewailing the lack of business. Next year when the good crops in the agricultural regions have come to market they will have the wherewithal and the desire to purchase largely according to their needs. No sane American need fear the question of an outlet for the production of this country's mines and mills next year. Good judges expect that with the improvement in producing facilities the future will break all previous records in metal production. Those that have not the foresight to accept this will lose by the lack of that discriminating quality. Judicious preparing for the future now will be rewarded manifold when the wheels of industry are running again at full speed.

The Iron and Steel Market.

August has not shown as much improvement in the iron and steel trade as was recorded for July. The most rational analysis of the movements seems to be that the general swing is upward, but with only a very slight trend, while there are movements in alternate directions from week to week or fortnight to fortnight.

Discussion of the iron and steel situation this year has run a great deal to percentages, and in some cases the period establishing the basis, or 100 per cent, has not been clearly stated. Assuming as representing full operation the first ten months of last year, productive activity during the first half of this year was a trifle above 50 per cent, but as exports declined only slightly, production for the domestic market was slightly below 50 per cent. In July and August production has been between 55 and 60 per cent, but for the domestic market only has been between 50 and 55 per cent. There is little probability that the percentage of total production will rise above 65, or possibly 70 per cent at any time this year. The sharp turn is likely to come as the new year opens, and is reasonably certain to carry production to a point between 75 and 100 per cent.

This system of figuring percentages has a serious drawback, as it leaves out of the account two very important considerations. One is that in the past the iron and steel trade has not been prosperous in direct ratio to the percentage of production to possible capacity, because with production less than capacity prices have been relatively unremunerative, whereas for about ten months prices have been quite well sustained despite the inactivity, and it is a question whether the new order has permanently supplanted the old. The other consideration is that production during the first ten months of last year, while representing undoubtedly the maximum output possible with the then existent equipment, does not represent the prospective capacity at all, there being plants recently completed, or in shape to be completed within a reasonable period, to increase the capacity shown in the ten months of last year by 15 or 20 per cent. Under the old order of things demand would have to mount up to 115 or 120 per cent, under the nomenclature commonly used, to indicate full engagement of capacity.

The improvement which has occurred in demand for steel products has been chiefly in the light lines and in those which are taken by the largest class of consumers. The large buyers, who place single orders involving large tonnages, continue conspicuously absent. The condition was foreseen by the best market judges long ago. The financial panic affected the large buyers the most, and particularly affected such orders as have to be financed. Thus the railroads are buying very little, and there is little being done in large structural contracts for bridges and buildings. On the other hand, the demand for sheets has shown a very steady, although gradual, increase since the beginning of July. Wire products, which are usually very dull in the two summer months, make an excellent showing compared with the second quarter. Merchant steel bars, hoops, bands, etc., have been steadily gaining. The distribution of steel in the various finished lines has undergone a complete rearrangement in the past 10 or 15 years, and has even been greatly modified since the slight depression in 1904. These light lines constitute a much larger proportion of the total output than they once did, and the trade depends correspondingly less on large rail and structural orders.

This change promises a greater degree of activity for the trade than could be discerned at present if one judged by the old standards.

PIG IRON.

There was quite a movement in Southern iron since our last report, which quoted the market weak at \$12, Birmingham, for No. 2. Sales were made at \$11.50 for foundry iron, and a large tonnage of low-grade iron was taken up, chiefly by cast-

iron pipe interests. This caused a reaction about the middle of the month to a straight \$12 basis, and at the close of the month it is difficult to find any iron at this price, nearly all sellers quoting \$12.50 or \$13. The Central West has not given as good an account of itself, as prices have been sagging, in the case of Bessemer and basic in quite a pronounced way, considering the smallness of the tonnages which have induced sellers to make lower quotations, while in foundry and forge iron there has been only a slight recession. We quote prices f.o.b. Valley Furnace as follows: Bessemer pig, weak at \$15.25, against \$16; basic, weak at \$14.75, against \$14.25; foundry iron, \$14.50 on the sand ton of 2268 pounds, against \$14.75 on the gross ton of 2240 pounds; forge pig, \$13.75, against \$14. Freight to Pittsburg or Cleveland is 90 cents.

FINISHED PRODUCTS.

A statement believed to be entirely authentic is to the effect that before October 1 the Pennsylvania Railroad will place a large order for rails for 1909 delivery, thereby giving up all negotiations on a tonnage for the current year. February 6 it definitely tendered orders to the rail mills for 55,000 tons for this year, at the flat price of \$28, but subject to new and more rigid specifications. A month later it developed that the rail mills had not accepted the orders and the matter has since been hanging fire. The Pennsylvania has in recent years bought from 100,000 to 200,000 tons a year, and while its requirements for the current year were scaled down to 55,000 tons the prospects are that the order for 1909, really covering the requirements of two years, will be quite large. The placing of such an order would probably lead other railroads to place orders for next year.

Billets have been very quiet, the official price remaining at \$25, Pittsburg. It is believed that this price has been shaded occasionally through the medium of conversion deals.

Finished steel prices are unchanged, except that light rails are somewhat firmer, commanding \$24 to \$25. The "official" price of \$28 is no longer heard of, having been a dead letter for some time. We continue to quote:

Standard rails, 50 lb. and heavier, \$28.

Plates, 1.60 cents for tank quality.

Shapes, 1.60 cents for beams and channels, 15-in. and under, angles and tees; tees, 1.65 cents; large beams, 1.70 cents.

Steel bars, 1.40 cents, base. Iron bars, 1.45 cents, delivered Pittsburg; 1.35 cents, f. o. b. Pittsburg for western shipment, and 1.50 cents, Chicago.

Sheets, 2.45 cents net for black, and 3.50 cents net for galvanized, 28 gage.

Tin plates, \$3.70 for 100-lb. cokes.

Wire nails, \$1.95; plain wire, 1.70 cents.

Iron Ore Production of the United States.

The iron ore produced in the United States in 1907 amounted to 51,720,619 long tons, valued at \$131,996,147 at the mines, according to Edwin C. Eckel, of the United States Geological Survey, whose report on the production of iron ores, pig iron and steel has just been published by the Survey as an advance chapter from "Mineral Resources of the United States, Calendar Year 1907." Compared with 1906, this was an increase of 8.32 per cent in tonnage and of 31.21 per cent in value.

Iron ore is mined for blast-furnace use in only 29 States of the Union, though it occurs in almost every State and Territory, and by far the greater part of the ore is mined directly by pig-iron producers for use in their own furnaces. The valuation which is placed on the ore is, therefore, entirely a matter of accounting. Some of the reports made to the Survey evidently include merely actual mining cost, others contain an allowance for a sinking fund, and in still others the figures given are obviously merely convenient prices to use in charging costs against the blast furnaces. The errors that result from these various methods, however, are almost entirely in one direction—that of undervaluing the ore. If all of the iron ore

were to be bought by iron furnaces in open market from an entirely distinct set of iron-ore miners, the average prices paid would probably be considerably in excess of those reported. In 1907 these prices ranged, for brown ore, from an average of \$1.01 per long ton in Arkansas and Texas to \$3.67 in Connecticut and Massachusetts, and for red hematite from \$1.06 in Kentucky, Maryland and West Virginia to \$3.24 in Wisconsin.

Reports of production in 1907 were received by the Survey from 169 mines, the maximum production of any one mine being 2,900,624 tons, from the Hull-Rust mine in Minnesota. Ten mines, all except one being located in Minnesota, produced over 1,000,000 tons each. The million-ton mine not located in Minnesota was the Red Mountain, of Alabama, which during 1907 produced 1,370,849 tons and ranks seventh in the list of producing mines given by Mr. Eckel.

The producing States are grouped by Mr. Eckel into four natural districts, defined by geographic and trade considerations. These are (1) the Lake Superior district, which in 1907 produced 80.51 per cent of the total ore mined, and which includes Michigan, Minnesota and Wisconsin; (2) the southern district, which produced 12.4 per cent of the total ore, and which includes Alabama, Georgia, North Carolina, Tennessee, the Virginias, Maryland, Kentucky, Arkansas, Missouri and Texas; (3) the northern district, including New England, New York, New Jersey, Pennsylvania, Ohio and Iowa, producing 5.46 per cent of the total; and (4) the western district, producing 1.61 per cent of the total ore, and including the States of Colorado, Utah, Wyoming, New Mexico, California, Washington and Montana.

The stock of ore at the mines on Dec. 31, 1907, amounted to 3,033,110 long tons, as compared with 3,281,789 tons similarly held on Dec. 31, 1906, and 3,812,281 tons on Dec. 31, 1905. The detailed figures given by Mr. Eckel, however, show that while the stock on hand at the mines on Dec. 31, 1907, was about 250,000 tons less than on the same date in 1906, the stock on hand at the lower Lake ports indicated an increase of over 1,130,000 tons.

During 1907 the United States imported more than 1,200,000 long tons of iron ore. Of this total over half was from Cuba and about a third from Spain. About 116,000 tons came from British North America, and the remainder was from numerous smaller sources of supply. The exports during the year amounted to 278,208 long tons, a slight increase over the exports of 1906. The bulk of these exports represent Lake Superior ores shipped directly from the American side to Canadian furnaces.

The data on iron-ore production which form the basis of Mr. Eckel's report are collected directly by the United States Geological Survey, requests for statistics being sent to every producing mine in the country. The data on the pig-iron and steel industries, presented in connection with those of the iron-ore industry, are collected by the American Iron and Steel Association and published through the courtesy of that association and of its general manager, James M. Swank. According to Mr. Swank, the production of pig iron in the United States in 1907 amounted to 25,781,361 long tons, as compared with an output of 25,307,191 tons in 1906, and of 22,992,380 tons in 1905. The small increase shown by 1907 over 1906 is due to the falling off in demand and production during the last quarter of the year. If the output of the first half of the year had been maintained, 1907 would have shown a total production of about 27,000,000 tons.

The production of Bessemer steel ingots and castings in 1907 was 11,667,549 long tons, against 12,275,830 tons in 1906, a decrease of 608,281 tons. The total production of open-hearth steel ingots and direct castings in the United States in 1907 was 11,549,088 long tons, against 10,980,413 tons in 1906, an increase of 568,675 long tons, or over 5.1 per cent.

Mr. Eckel's report is ready for distribution and may be obtained by applying to the Director of the Geological Survey, at Washington, D. C.

Manganese Ores.

A recent report, published by the United States Geological Survey, deals with the production of manganese ore in 1907, the author being E. C. Harder.

The production of manganese ores in the United States in 1907 was 5604 long tons, valued at \$63,369. Compared with 1906, this is a decrease of 1317 long tons, or 19 per cent in quantity, and of \$24,763, or 28 per cent in value.

As usual, the bulk of the production—4604 long tons, valued at \$56,469—was in Virginia. South Carolina joined the ranks of producers for the first time since 1903, and its output of ore—800 long tons, valued at \$4,800—was greater than in any previous year. Tennessee and California also showed increased production in 1907. On the other hand, Georgia and Arkansas, which contain some of the most important manganese deposits in this country, were not among the producers in 1907. The Utah mines were idle throughout the year.

The larger part of the ore mined in this country in 1907 was used in the brick, paint and chemical industries, only about one-sixth (947 long tons, valued at \$6,747) being used in the steel industry, as against 209,032 long tons imported for this purpose. The main reason for this distribution of the product seems to be that although the demand in the first-named industries is limited, the prices paid are higher and ores can be used which would be undesirable in steel manufacture. Besides, the mining is on so small a scale that the supply does not run far ahead of the demand in these industries.

The small domestic production of manganese ores and the small portion of even this product used in making spiegeleisen and ferromanganese makes the importation of foreign manganese ore a matter of considerable importance to the iron and steel industry of this country. The imports for 1907 amounted to 209,032 long tons of manganese ore, valued at \$1,793,143, a decrease in tonnage, but an increase in value as compared with those of 1906, indicating that the price of foreign manganese ore has risen.

Ferroboron Prize Competition.

As was briefly noticed in our last issue, the rules for the ferroboron prize competition have recently been published. We now give them in full:

The sum of \$500 has been paid by the Pacific Coast Borax Company to the American Electrochemical Society and deposited in trust as a research fund to be awarded as a prize under the following conditions:

The Pacific Coast Borax Company desires to awaken an interest in research work which may lead to some improvement in the commercial method of manufacturing ferroboron by a direct process from colemanite.

It is essential that the process should be sufficiently economical and suitable to be applied on a large scale so that the finished product may be available for commercial purposes. (Commercial ferroboron, as now made, contains 20 per cent or more of boron, less than 3 per cent of carbon, and sulphur and phosphorus are practically absent.)

The prize has been deposited with the American Electrochemical Society, with the request that the Board of Directors award the same for the best practical solution of the problem, under reasonable conditions, to be decided upon by the Board of Directors.

In accordance with the above request, competitors for the prize are notified that they must comply with the following conditions:

1. The treatise on the subject must be in typewritten form and accompanied by a sample produced by the process described in same.
2. The competition for the prize is open to any one and is not restricted to members of this society. The treatise on the subject must be enclosed in a plain, sealed envelope, not bearing the author's name, but identified by a pseudonym. The

outside of the envelope, containing the paper, must be labeled with the pseudonym and with it should be sent another plain sealed envelope, also labeled with the same pseudonym, which should contain inside the envelope the name and address of the competitor. Both these envelopes should be sent to Prof. Morris Loeb, 273 Madison Avenue, New York City.

3. All papers competing for the prize must be in the hands of Prof. Loeb before Oct. 1, 1909. Prof. Loeb shall retain the small sealed envelope, containing the address of the competitor and forward the large envelope, containing the treatise, as well as the sample of the product, both merely labeled with the pseudonym, under cover, to the secretary of the American Electrochemical Society, to be submitted to the Board of Directors, who will award the prize. In this manner, as the treatise must be typewritten, the board can act with entire impartiality and the paper shall be judged on its own merits, so that the author's standing can have no influence whatever on the decision. The competitors for the prize forfeit none of their property rights in the process submitted.

4. As soon as the Board of Directors has agreed upon the best treatise, it will request from Prof. Loeb the address of the author thereof, who will then be required to demonstrate his process before the prize will be finally awarded.

5. The Pacific Coast Borax Company, 100 William Street, New York City, has offered to supply any one who desires to compete for the prize seriously with all the crude colemanite that the parties making the experiment may require, provided that the request for this colemanite be accompanied by a letter signed by one member of the Board of Directors of the American Electrochemical Society, endorsing the application for the material. This condition is merely made so as to furnish the material only to those who may have the proper qualifications to experiment intelligently and with some chance of success.

For the convenience of competitors who may desire to consult some of the published literature on the subject a brief bibliography is herewith attached.

II. Moissan and G. Charpy, *Sur l'acier au bore*, *Comptes Rendus*, 1895, vol. 120, p. 130.

M. L. Guillet, *Les aciers au bore*, *Revue de Metallurgie*, August, 1907, vol. 4, pp. 784 to 796 (translated in abstract in "Electrochemical and Metallurgical Industry," 1907, vol. 5, p. 421).

A bibliography on boron and borides in general may be found in O. P. Watts, an investigation of the borides and silicides, *Bulletin University of Wisconsin*, No. 145 (Engineering Series, vol. 3, No. 3, 1906).

CORRESPONDENCE.

Radioactivity.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—Some years ago you published in your vol. 2, p. 160, a letter from me in which I suggested that the sensible heat shown by the salts of radium might possibly be produced by some unknown rays from some extraneous source to which the salts of radium are opaque or partially opaque, thus converting some of the energy of these unknown rays into heat rays and thus rendering them perceptible to our sensations and to scientific measurement.

It seems to me that it would be of interest, first, to see whether any substance could be found that would appreciably alter the difference in temperature between radium salts and the material in juxtaposition to them.

For instance, if a box of platinum would reduce the difference between radium and the surrounding objects to one-half the usual increment of temperature—all other conditions being alike—it would indicate that platinum was partially opaque to these unknown rays.

It would also be of interest to test the heat increment in a given specimen of radium salt under carefully determined conditions at various different points on the surface of the earth, thus learning whether the intensity of this unknown energy varies, as does, for instance, the intensity of the magnetic force, and whether the geographical distribution of the intensity of these unknown rays bore any relation to the geographical distribution of magnetic force, or had any connection with the inclination or declination of the magnetic needle.

GODFREY L. CABOT.

BOSTON, MASS.

* * *

Worlds in the Making.

To the Editor of Electrochemical and Metallurgical Industry:

Your editorial on "Worlds in the Making" in the August issue calls attention to a very interesting subject, namely, the increasing percentage of carbon dioxide in the atmosphere due to the increased consumption of coal, and the consequent effect on the increase of plant life. The truth of the argument cannot be denied. The open question is merely a quantitative one; that is, whether the effect is appreciable. I understand that we are taught that in the early history of this earth, when it was a molten mass, there was no free oxygen and that our present source of oxygen comes from the production of coal by the plants from the gaseous carbon dioxide. If this is correct, it must necessarily follow that when we have burnt up all the coal on this earth, the oxygen of the air will all have been consumed again and plant life will then again be the chief form of life on the earth.

There is, however, another slow, but sure action which is taking place and which also affects the chemical history of this "insignificant, tiny world of ours," and which was not mentioned in your editorial, nor have I seen it mentioned anywhere else, although it is quite possible that it has suggested itself to others also. I refer to the slow, but continuous increase of oxygen in our atmosphere, due to our artificial reduction of the oxides of metals found in the earth. By far the greater quantity of the metals which we produce are originally in the state of oxides from which we reduce them, chiefly iron. Among these should be included also the limestones, which we now use so largely in the production of cements, and which in this process give off carbon dioxide as a gas. All this oxygen has, since the formation of this world, been combined in solid form with the metals and has, therefore, never been available for animal life as atmospheric oxygen; this is now being set free in large quantities, generally in a form in which it becomes a part of our atmosphere. Only very little of it gets back into the earth in the form of solid oxides of the metals which we have reduced, as our stock of reduced metals is increasing very much faster than it is consumed by oxidation.

It is true that the oxygen thus obtained from the metals is first set free, as a rule, in the form of carbon dioxide, as most of our reductions consist in transferring the oxygen from the metal to carbon. But as is well known and as was pointed out in your editorial, the function of plant life is to reduce carbon dioxide to carbon (wood) and oxygen. Hence the setting free of this oxygen which was combined with the metals, involves the aid of plant life.

That the above argument is correct probably no one will deny, but there is naturally another feature involved, namely, the quantitative one. Is the quantity of oxygen, which we are now adding to the air, sufficient in amount to have any appreciable effect? Is plant life increasing at a corresponding rate so as to reduce this carbon dioxide to oxygen? Is animal life increasing faster than in proportion to this addition to our oxygen? When left to nature, an oscillation or wave motion generally takes place, which oscillations ultimately die out, in this case the frequency being measurable in geological ages. Formerly, carbon dioxide was in excess and plant life consequently flourished,

setting oxygen free, thereby increasing animal life and diminishing plant life; the wave may now be reaching its turning point, the carbon dioxide increasing again, and if continued would decrease animal life and increase plant life until another turning point is reached, and so on, each oscillation being likely to be less than the preceding one. The changes are so slow that it need not trouble the present generation and is therefore only a matter of interest to us and not a matter of concern.

Those who are engaged in the good work of urging the preservation and extension of our forests, can add to their other good arguments, that plant life should be encouraged in order to check the increased percentage of carbon dioxide and to enrich the oxygen by setting free that which we are getting from the metallic oxides of the earth.

PHILADELPHIA.

CARL HERING.

* * *

Treatment of Iron and Steel in the Electric Furnace.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—It does not appear from the interesting article by Major Stassano on the "Treatment of Iron and Steel in the Electric Furnace," published in your August issue, that the assertion made in the note on "The Lash Steel Process and the Electric Furnace" (your vol. 5, No. 11, p. 455) is altogether incorrect, although that is apparently the intention of the article.

The assertion in question was to the effect that at the present time the direct production of steel from ore in the electric furnace is not commercially feasible on account of certain technical difficulties. The disagreement in the matter is possibly one of words, for it will be observed that Major Stassano speaks of having solved "the difficulties which interfere with the practical solution of the problem." Much depends upon the meaning to be attached and to the expression, "practical solution."

According to Major Stassano's work the consumption of power in the direct production of steel from the ore amounts to 4 kw-hours per kilogram at the least, and the cost of lining the furnace amounts to \$1.93 per ton of output. While there are doubtless places where electric power can be developed very cheaply, and while no doubt in the future this very cheap power will become somewhat more common than it is at present, it is generally wise in calculating the cost of electric furnace processes to arbitrarily assume that electric power at the furnaces will cost \$15 per horsepower-year.

If then 4 kw-hours are used per kilogram of steel the energy required for producing one ton (2000 lb.) would be 4880 hp-hours, which would cost \$8.37, and thus the cost of power and furnace lining alone would, according to Major Stassano's results, be \$10.30. Except in special cases, or for the production of special grades of steel, this charge would prevent the commercial application of the electric furnace.

According to experiments made with the Lash Process, so far as these have gone, the total cost of treatment in the electric furnace is very much less than that calculated for power and lining from Major Stassano's results.

FRANCIS A. J. FITZGERALD.

FITZGERALD AND BENNIE LABORATORIES,
NIAGARA FALLS, N. Y.

* * *

Steel Foundry Practice.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—In reproducing the photograph (Fig. 2) showing test specimens in connection with my letter on "Steel Foundry Practice," published in your August issue, I see that the descriptive heading, "Unannealed Basic Open-Hearth Cast Steel," was omitted. This leaves the article without any mention of the fact that the test pieces were not annealed, and as that is really the only interesting feature about them, I

know you will be glad to rectify the unintentional omission of the word "unannealed" by giving space for this letter in your next issue.

R. A. BULL.

GRANITE CITY, ILL.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—On the eve of sailing for Europe, permit me to say a few words in reply to Mr. R. A. Bull's criticism published in your August issue.

Mr. Bull accuses me of unfairness because of a statement that there was room for improvement and progress in making high-grade steel castings. I am not a foundry man and my remarks were simply based on what I was told by a great number of casting consumers; quite a number even told me that they were obliged to abandon steel castings owing to poor qualities and substitute forgings at a much higher cost.

To these makers it will no doubt afford a great relief to know that there is at least one concern and possibly more where they can obtain what they have been looking for in vain.

As to the excessive loss in the production of lighter steel castings and odd shapes, the information was given to me by a practical foundry man of a large company, who told me his company dropped the light-weight and odd-shape castings on account of heavy losses in the foundry. He fixed the average percentage of loss at 50 per cent.

I have no doubt that there are intelligent and progressive foundrymen like Mr. Bull, and I had, of course, no idea of underrating their merits. I merely desired to show how much better they could do if they had an opportunity to purify and refine their metal in an electric furnace. I did not intimate that the trouble was due to the foundryman's lack of intelligence, but entirely to the lack of sufficiently uniform and pure material.

As to the La Praz laboratory sheet I would say it is a part of a continuous run of a month's production to prove the purity of the metal we can produce from cheap raw materials.

The heats are all high-grade tool steel of a great variety of tempers with no idea of making them uniform. We, of course, can almost get exactly what we aim at in the Héroult furnace and can come much nearer to the mark than is possible in crucible or open-hearth practice.

In conclusion, I regret that Mr. Bull should have considered my incidental remarks relating to the steel foundry business in the nature of an attack upon himself and his associates. If he has been under that impression, I sincerely trust that the foregoing will entirely remove it.

After all, there is no harm in discussing questions of this sort; it can only be productive of good and further progress.

NEW YORK CITY.

R. H. WOLFF.

* * *

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—In your August issue there is a letter by Mr. R. A. Bull taking exceptions to Mr. R. H. Wolff's comparisons between electrical steel making and that of other steel-making methods. The writer agrees with both gentlemen that electrical smelting is destined to occupy a prominent position in steel making in the United States and would venture the opinion that the electric furnace's place will eventually develop as a valuable adjunct to established practice, such as the bessemer and open-hearth processes, by taking metal produced by them and submitting it to a greater degree of refinement than is possible by either.

Mr. Wolff's statement that the losses in steel-foundry practice are 50 per cent, may not be so misleading as Mr. Bull would have it. In Mr. Bull's opinion the statement is unfair. I desire, from a sense of fairness also, to prove that Mr. Wolff's statement has some elements of truth about it. The statement of such loss does not refer, as I take it, to one plant's practice, but rather to the steel-casting industry as a whole.

According to Mr. Bull's words the average yield is only 68 per cent on basic melting and included in the loss is an item of 4 per cent for defective castings. Mr. Bull's practice is not

that of a general product, but is mainly repetition work on specialties with a large percentage of it made on molding machines, and consequently the chances for high losses in defective castings should be reduced to the lowest possible figures. In a general or jobbing shop with a great variety of shapes the conditions are entirely different, as I will show. Mr. Bull has committed the error of thinking his practice as representative of the steel-casting industry at large.

The differences between metal charged and metal yielded varies with the shape and character of the castings turned out in salable form. Car fittings, such as bolsters, truck frames, etc., for both freight and passenger service, are comparatively light in weight, and will average about 600 lb. per casting. The loss in gates and risers on such designs is practically 7 per cent. Adding to that the loss in melting, skulls, fins and bad castings makes it comparatively easy to show a yield of 68 per cent of metal charged as good castings. Since Mr. Bull's product comes within the class of work just mentioned, a yield of the afore-mentioned figure is not exceptional, mainly because the kind of product does not greatly decrease the yield through a heavy loss in gates and risers.

Coming to a general or jobbing practice it will be seen that Mr. Wolff's statement is not wide of the mark. The writer has knowledge of a steel foundry producing a great variety of work which may be a small gear, the head of a molder's rammer or the sternpost of a *Dreadnaught*. The weight per casting may vary from a pound or two up to 100,000 lb. (one hundred thousand pounds).

In the particular foundry the methods are strictly up to date, the staff highly intelligent, progressive and alert, yet they think they are doing well if in a month's run on such contrasting shapes and weights the records show a yield of only 55 per cent of good castings from metal charged. The loss in bad castings does not exceed 5 per cent, but owing to a great many heavy castings, the loss in gates and risers is excessive. Large, massive castings require large, massive risers; bolsters, truck frames, knuckles and drawbars require small, light risers, and in some cases no risers at all. (It is the feature of heavy risers, resulting in a low yield, that has led Mr. Wolff to conclude that modern steel foundry methods are wasteful.) Take, for instance, a locomotive frame weighing 6000 lb. Such a casting necessitates a gate and risers totaling 2000 lb. An unavoidable loss of 33 per cent in non-salable metal. Other instances could be cited in support of such facts, which can be confirmed by progressive steel-foundry men.

A foundry report showing a certain loss in defective castings during a certain period may fluctuate through a variety of causes. A loss of one large casting would make a disastrous showing. Such a thing happens, yet the incident would not necessarily prove that the management was not progressive.

Another factor controlling a foundry report of good and bad castings is the system of inspection. It may be rigid or it may not. The inspection may be done by the plant's staff or it may be done on the ground by the customer. It is not the rule for the producer to inspect a casting from the customer's point of view. Conscientiousness varies with individuals. Records of replacements are not public property. Inspected castings are delivered to customers, but *sometimes* they are returned to the manufacturer and remelted. Pointing with pride to a month's report showing a low loss could be shamefaced if charged against it at a later period was one or more replacement orders.

Open-hearth methods have reached a creditable degree of growth in quality and tonnage. Like the Bessemer process they have practically reached the limit in the matter of quality. The product of to-day is the best that can be made with the materials and fuels available. The steps in open-hearth practice for future developments must come in the form of reducing the cost of repairs, simplifying the operation of furnaces, lengthening their life and producing larger tonnages with greater speed from larger sizes.

Mr. Wolff points out that losses in the steel-casting industry

are due to the sluggishness of the metal. That fault is not by any means common and if it does occur it is due entirely to operation under some adverse circumstance or possibly at rare intervals, the personal equation. If the furnace is in good repair, has the advantage of good fuel and stock, there is no excuse for sluggishness.

I am sure Mr. Wolff will agree that faults can occur with his electrical furnace and produce results equally as bad at times as can the open-hearth, the converter or the crucible. I will grant the gentleman that his device or process offers a possibility of yielding steel of *greater* purity and *better* quality than is possible by existing methods of steel manufacture, but I do not believe that he can with the assistance of his electrical furnace make the molder commit fewer errors, cause castings to strip more cleanly of burned sand, eliminate shrinkage and its attendant evils and *lessen* losses resulting from gates and risers.

Let the steel produced by *any* method be ever so pure or ultra-refined, the drawbacks cited (I could elaborate on them, but it is painful) will be like the get-rich-quick promoter, always on the job. I for one do not know that the American steel casting industry is in want of hotter or less sluggish steel. The methods we have give us that quality. But there is a burning longing for fewer losses of the kind above mentioned. The writer knows he voices the sentiments of American metallurgists in welcoming the adoption of the electrical furnace. He cannot refrain from the doubt that it promises greater yields, fewer bad castings and greater financial profits.

Since Mr. Bull's plea is one of fairness, permit me to refer to his chart of comparisons showing analyses of basic steel and electrical steel. It is the intention I take it to show progress in basic practice. The chart and the purpose of its comparison cannot be applicable to electrical furnace operation. It fails to show progress in basic practice.

No relation exists between unlike methods and unlike conditions. The chart marked October, 1900, refers to steel made in *tilting* furnaces of admittedly poor design, fired with producer gas. The practice at that time was the best that could be attained with the materials, furnaces and fuels. The chart marked May, 1908, refers to steel made in *stationary* furnaces fired with fuel oil. If Mr. Bull will refer to his records he will find that in the early part of the year 1900 the steel produced at that time was the best in the history of the company and at times showed losses fully as low and lower in defective castings than what Mr. Bull considers good practice at this date. In that respect alone there is not any evidence of progress.

In the 1900 chart the sulphur is shown as soaring to 0.054 per cent. On that particular occasion some very high sulphur coal was fed to the producers unknowingly. The reputation and record of the steel melter should not suffer if in 1908 the other fellow is so favored by circumstances as to have oil for fuel so low in sulphur that there is no contamination of the bath. Leaving out the one high sulphur heat in 1900, the year 1908 does not show any degree of desulphurization in the basic-open-hearth to the detriment of practice conducted eight years ago. The year 1900 kept below, in the maximum of phosphorus, standard specifications, but it went the 1908 chart 0.004 better in the refining of that element.

I trust you will give the foregoing remarks space in your publication, since from my point of view and acquaintance with steel foundry practice Mr. Bull has not refuted Mr. Wolff's arguments. Electrical methods are undoubtedly becoming recognized and your journal has done valuable work in disseminating knowledge concerning them. Therefore, in asking for your space, it is with the conviction that some few truths should be given your readers concerning steel-foundry practice from one who does not desire to put himself on record as "one who knows," but as one who wishes to know and that others may acquire, a few facts given without dissimulation.

NEW YORK CITY.

W. M. CARR.

Electrolytic Refining of Gold, Silver and Copper at the United States Mint, San Francisco, Cal.

BY ROBT. L. WHITEHEAD.

Gradually all the mints have been equipped with electrolytic processes for refining their metals; Philadelphia first, then Denver, and now the sulphuric acid process, in use for over 30 years, has been completely replaced at San Francisco by the most modern equipment installed in any of the mints.

The system of refining as first installed at the Philadelphia mint, though largely experimental, developed the fact that the electrolytic method was cheaper, gave a purer metal for coinage and saved by-products of great value which by the old acid processes were either lost or remained in the finished coin.

The Denver mint was equipped by the writer two years ago with electrolytic refining processes. As shown by the report of the director of the mint for the fiscal year ending 1906, he considered this the most modern equipment in the service. From the experience and results obtained there, the writer was enabled to install in the mint at San Francisco an equipment which

The rolling and hydraulic press room is the next in order, the dimensions being 18 ft. x 40 ft. Opening from this room is a storeroom for supplies. The vault for storing all the metals in the foreman's charge not actually in the process of refining has a convenient location in this room.

In the attic, access to which is obtained by a winding staircase from the rolling room, are located the condensing chambers for the melting furnaces, two Rockwell steam pumps for forcing oil to the furnaces, and a steel storage tank of 2000 gal. capacity. This tank is supplied with fuel oil by a force pump from the main storage tank in the street, which has a capacity of 10,000 gal.

The care and comfort of the men has not been overlooked, as toilet, shower baths and dressing rooms are provided, which open directly into the operation rooms. In order to give an intelligent idea of the equipment it will be necessary to take each room separately.

The Tank Room.—(Fig. 1.) The floor of this room is laid with acid-proof stone slabs, 2 in. thick, the joints being litharge and glycerine cement, which in reality is waterproof, but not acid-proof. The Wohlwill process for gold refining is used, the same process for gold refining being applied in all the mints. (See the articles by D. K. Tuttle and E. Wohlwill, this journal, Vol. I, p. 157, and Vol. II, p. 221 and 261.) For this equipment 30 specially designed Royal Berlin porcelain tanks, 18 in. long, 13 in. wide and 12 in. deep, are arranged on a 2-in. stone table, which is supported by white enamel brick pillars. The tanks are arranged in two rows of 15 tanks each.

The circulation is obtained from an individual flow from a porcelain trough, which is supplied from a jar 36 in. x 24 in. in diameter, which receives the discharge from a porcelain plunger pump made specially to withstand the chemical action of chloride of gold solution containing free hydrochloric acid.

The pump, as shown in Fig. 2, has an overflow pipe from the discharge jar into the pump tank. This prevents a "spill." Tops are provided on the troughs, discharge and pump tank to prevent spattering and cooling.

By adjusting a spigot in the bottom of the discharge jar, the flow to the trough is regulated. The flow to each tank is regulated by the openings from the trough; the tanks are so constructed that the solution enters the back end of the tank and draws from the bottom, thereby constantly removing the heavy gold chloride, which sinks to the bottom, into a trough which carries it to the pump tank to be circulated again.

By this arrangement of circulation each tank has its own individual flow of electrolyte, and can be regulated fast or slow as conditions warrant, thereby obtaining a uniform mixture of solution which is both quiet and constant. This is in striking contrast to the propeller circulation in use in the other mint refineries. This arrangement makes it easy to properly take care of the electrolyte, as there is only one solution for the tanks. A few assays a day is not very much. But when it amounts to 50 the result may be that no tests are made of the solution for months at a time, and the man in charge of the tanks is governed entirely by the character of the deposit, while all the time he may have 1 or 2 per cent more gold in solution than is neces-

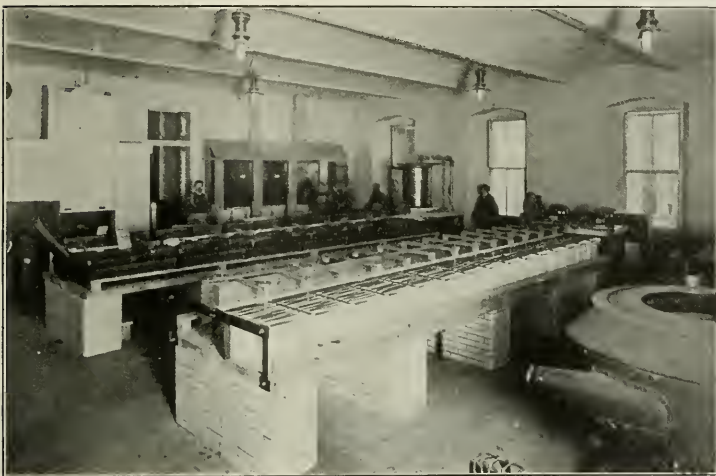


FIG. 1.—TANK ROOM.

far exceeds the Denver equipment, both in size and with respect to improvements, so that the San Francisco mint is now the most up-to-date plant of its kind anywhere installed.

The allotment of rooms set apart for this purpose by the superintendent has greatly added to the efficiency of the equipment. For each distinct operation a separate room is provided so that the element of crowding, which is so apparent in the other mints, has been eliminated. The tank room, which is 41 ft. x 52 ft. in size, has windows on both sides. This insures proper ventilation and a working atmosphere comparatively free from fumes.

The generator room has dimensions of 16 ft. x 26 ft., with three windows. In this room are located four motor-generator sets and a controlling switchboard.

Three rooms are set aside for the laboratory of the refinery. The smelting room is 34 ft. x 30 ft. in size and also has windows on either side. In some respects this is a disadvantage, since the fine dust that invariably floats around melting rooms will be taken out by the draught.

An office and weigh room for the foreman opens into both the melting and rolling rooms. All metals received for refining are first weighed here before receipting for them, and also all fine metals are weighed before delivering to the melter and refiner.

sary. Those in charge of outside electrolytic plants will appreciate the force of this argument.

As the objections to the propeller system of circulation are so numerous and will not interest the readers of this article, I will only mention a few. First, the violent agitation is confined to one place, leaving the ends of the tank with very little circulation and hastens the formation of slimes. The chloride of silver formed on the anode is dislodged and floats around the tank; some of it adheres to the cathode and is covered up with

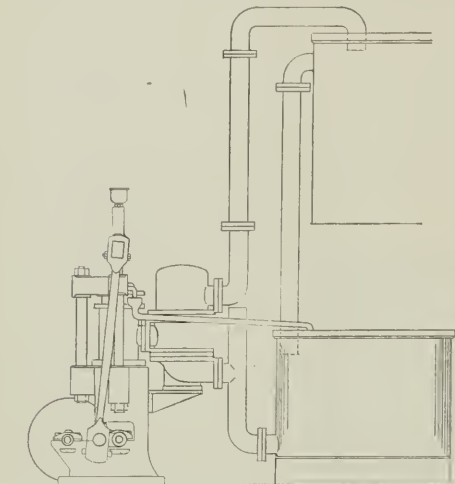


FIG. 2.—PORCELAIN PUMP AND CONNECTIONS FOR CIRCULATION OF GOLD ELECTROLYTE.

fresh deposit, or if sufficiently large forms a short-circuit. The most serious objection, however, is the swirl of the solution which throws the slimes to the ends of the tank and gradually causes short-circuits, so that more frequent shut-downs for cleaning out are necessary. The space in the tank occupied by the propeller rigging robs the tank of depositing surface, curtailing the production per tank.

A majority of these objections are overcome by the trough circulation. This does away with the objectionable feature of

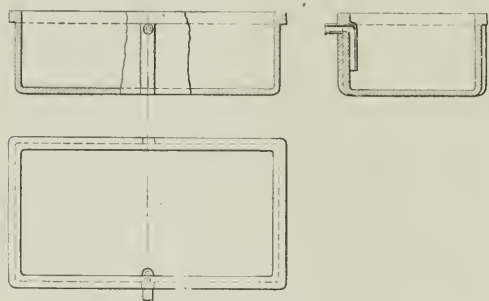


FIG. 3.—EARTHENWARE TANKS FOR SILVER SOLUTION.

putting gold chloride acid into each tank with a pitcher. When it becomes necessary to enrich the electrolyte the proper amount can be added to the pump tank and the same may be done with acid, while, when it is necessary, to draw off the foul solution, this can be done from an opening in the end of the trough without disturbing the operations in the tank. The anodes and cathodes are $\frac{3}{4}$ in. apart, requiring only 1 volt per tank to main-

tain 450 amp. This gives a current density of 105 amp per square foot of cathode surface, giving an output of gold per 24 hours per tank of 650 to 675 oz. The best run for one week with 20 tanks in circuit was 13,500 oz. per day. The fineness of the melted cathodes averaged 999.5.

The purity of the anodes varied from 880 to 960 in gold. Anodes having as much as 100 pts. of silver have been worked successfully producing gold 999 in fineness.

The silver tanks (Fig. 3) are of German earthenware and a similar arrangement of circulation is employed. For this purpose an earthenware centrifugal pump is provided, as shown in Figs. 4 and 5. The horizontal or Thum system of parting silver is used. It will only be necessary to describe the new features attached to it as the details of the process are well known to the readers of this journal.

The tanks are 24 in number and are $39\frac{1}{2}$ in. long, $19\frac{1}{2}$ in. wide, 12 in. deep, arranged on a 2-in. stone platform supported by enamel pillars, the construction being the same as that of the gold-tank foundations. The anodes are made up 300 and 333 pts. gold, not over 100 pts. base, the balance being silver. The

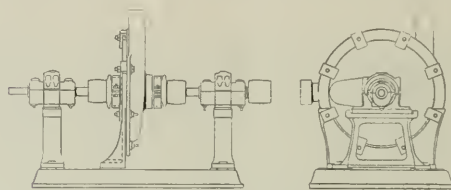


FIG. 4.—CENTRIFUGAL STONEWARE PUMP FOR SILVER ELECTROLYTE.

electrolyte contains from 1 to 2 per cent free nitric acid, $\frac{3}{2}$ to $4\frac{1}{2}$ per cent silver, besides lead, copper, bismuth and zinc. As the anodes are very base, about 5 per cent by volume of the electrolyte is drawn off each day and an equal volume of solution very rich in silver is added. This is sufficient to keep the electrolyte pure enough to make a coarse, sugary deposit.

The trough circulation is used in the silver tanks to the same advantage as in the gold tanks. The electrolyte having a uniform composition, practically the same current density is kept in each tank, about 50 amp per square foot of anode surface.

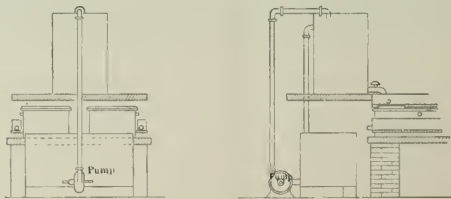


FIG. 5.—PUMP AND CONNECTIONS FOR SILVER TANK.

The anode contact piece is cast into the anode slab, thereby obtaining a more perfect contact. The current going directly into the slab acted upon, one set of contact pieces is sufficient, for as soon as the slab into which it is cast shows disintegration it is cast into a fresh slab.

The foul solution that is drawn off is freed from silver by copper plates. The silver thus recovered is used in making silver nitrate to replenish the electrolyte. The waste solution is sent to the iron tank to recover the copper.

The deposited silver runs uniformly about 999.5 in fineness, the anode residue of gold is washed free from silver and melted and cast into anodes varying in fineness from 920 to 950 in gold. It will be observed that there is no boiling with nitric acid.

In the refineries of the other mints the devotion to old methods with which the men are familiar, is still shown by the fact

that the foul silver solution is purified by precipitating the silver with salt as chloride. The copper present as nitrate is run into the sewer, this metal apparently having no value because the government has not paid for it. At the same time, should platinum in small quantities go into solution, it would be lost through the same channel.

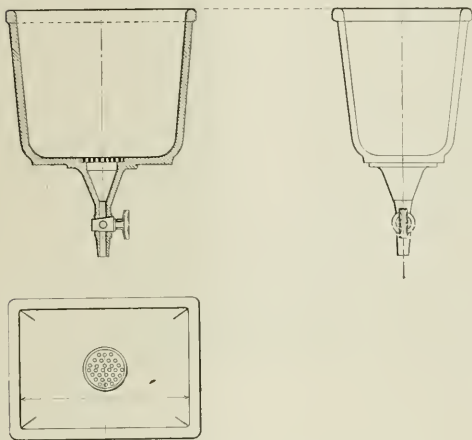


FIG. 6.—PORCELAIN AND EARTHENWARE FILTERS, MOUNTED ON BRICK.

By using the proper equipment and a little care the copper can all be saved. The recovery of silver as chloride is a relic of the old nitric acid process, which served its purpose, but in this age of advancement should be a thing of the past.

In this room all the products of gold and silver, excepts tops and cathodes, are washed in earthenware centrifugals. The

handled with ease and can be readily melted in plumbago crucibles, if rich in values.

The entire porcelain and earthenware equipment, as well as the centrifugal washers and dryers, were furnished by J. W. Sitting, of New York, who has supplied the government with this ware for a number of years.

The system of making gold chloride, which was worked out by the writer previous to the installation of the Denver refinery, is now in use in the different refineries of the mints.

The process consists in passing an electric current through a solution of strong hydrochloric acid (no nitric acid being used in the solution) with anodes of gold, 990 or over in fineness, while the negative pole of the circuit is connected to a cathode of rolled gold suspended in a porous cup filled with strong hydrochloric acid, the cup being immersed in the bath. The current is forced through the bath at a pressure of 5 volts. During the operation considerable heat is generated, the cathode surface being small for the high current used, namely 200 amp at 5 volts.

There is considerable evaporation of acid, both in the bath and the cup, and the bath has to be replenished with acid from time to time. An acid-proof stone hood is used for this operation, which is shown in the photograph of the tank room, Fig. 1.

In this hood are five porcelain tanks. They are 24 in. long, 15 in. wide and 15 in. deep. They have a capacity of 2000 oz. per day of fine gold. This equipment is larger than is necessary, so that ample time can be taken to properly care for the operations of the process, and keep an ample supply of gold chloride always on hand.

There are in this room three lead-lined tanks, each 36 in. long, 18 in. wide and 18 in. deep, which are used for copper electrolysis. The copper recovered from the nitric and hydrochloric acid solutions contains gold, silver and platinum metals and is treated electrolytically to obtain copper sufficiently pure for alloy, the gold, silver and platinum being found in the slimes. The slimes from the copper tanks are treated separately and melted into a bar, which is worked up separately to recover the platinum, which in a year's time amounts to about 400 oz.

As the deposits contain only a very small amount of platinum, no effort is made to make a separation from the electrolyte with sal ammoniac. After the gold has been precipitated with ferrous chloride and sulphate, the platinum is thrown down with the copper by scrap iron.

As will be noticed from this article, the refining at the United States Mint in San Francisco is entirely electrolytic. Nothing either in the equipment or operations reminds one of the sulphuric or nitric acid processes, while the refineries in the other mints still adhere to boiling and precipitation methods.

A method for refining the gold slimes produced in the Wohlwill process was perfected, and 12 additional tanks were ordered to take care of this process. This method is also entirely electrolytic, but it is too early to describe it further.

The system of removing the copper from the nitric and hydrochloric acid solutions is quick and very complete. A lead-lined tank, 7 ft. long, 4 ft. wide and 4 ft. deep, contains a perforated lead basket, filled with scrap iron and suspended two-thirds the depth of the tank. An earthenware syphon pumps the solution over and over, until free from copper. After settling, it is run into an intermediate settling tank before going through the



FIG. 7.—GENERATOR ROOM.

washing is very quick and complete, and the precipitates are sufficiently dry to put in a melting pot without further drying.

This is the first mint to use this system of washing, which has proved highly satisfactory. Cement copper, which is one of the most difficult products to wash free from iron salts, is

two settling tanks in the yard and then into the sewer.

The general opinion is that the nitric and hydrochloric acid solutions dissolve the lead lining of the tanks, but a hard-lead lining of special composition is used, and after three months of hard use in contact with boiling solutions containing both acids in the free state neither tank has developed a leak.

The ferrous chloride formed in precipitating the copper furnishes two-thirds of the iron salt necessary to precipitate the gold from the foul solutions.

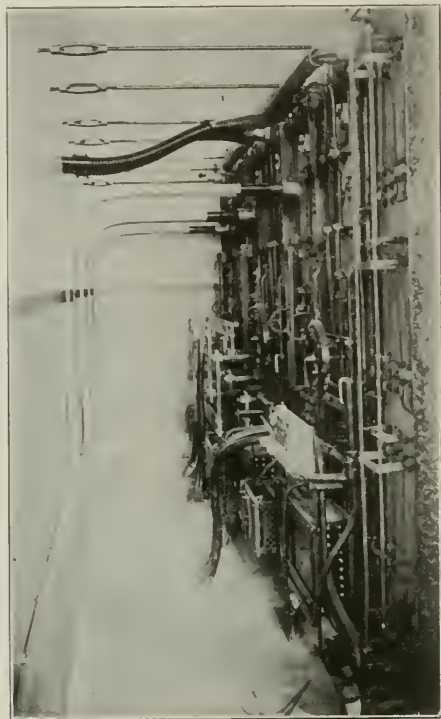


FIG. 8.—BACK OF MAIN SWITCHBOARD.

During three months' operation of the refinery 500 lb. of copper was recovered from the gold operated upon. From this copper 112 oz. of platinum and iridium were recovered. The slimes from the copper electrolysis produced a bar assaying 83 parts of platinum per 1000 oz. This represents a concentration from 1,073,300 standard ounces of gold, which, if the platinum were evenly distributed, would make less than one-tenth of a point per 1000 oz.

The next in point of importance is the **generator room**, Fig. 7. There four motor-generator sets are located, as follows: Two sets produce 1000 amp at 15 volts, one each for gold and silver. One set for gold chloride electrolysis produces a bar assaying 83 parts of platinum per 1000 oz. This represents a concentration from 1,073,300 standard ounces of gold, which, if the platinum were evenly distributed, would make less than one-tenth of a point per 1000 oz.

Each of the large sets can be operated independently on either the gold or silver tanks, or both sets can be used together on one system; or one set at a time can supply current to both gold and silver tanks. By this latter arrangement the highest efficiency can be obtained from the machine when the refinery is not running at its full capacity, and at the same time one set will always be idle. As the gold chloride set is not running continuously, ample time can be found for repairs without inconvenience to the operations in the tank room.

The switchboard, the location of which is shown in the photograph of the generator room, Fig. 7, consists of seven panels of acid-proof stone, three motor panels and three generator panels with one panel for controlling the auxiliaries in the refinery, namely: two small motor-generator sets; two centrifugals with a 5-hp motor on each; one elevator for filtering purposes, operated by a 5-hp motor; one rolling mill with a 15-hp motor; two pumps with a 3-hp motor on each; one hydraulic press with a 5-hp motor; one Sturtevant fan blower with a 10-hp motor.

The total length of the board is 15 ft. 6 in., and the height from the floor is 8 ft. The board is equipped with the usual instruments for controlling the motor-generator sets, and, in addition, each motor panel has a Sangamo watt-hour meter for registering the watt-hours consumed by the motor on each individual set. Each generator panel also has a Bristol recording ammeter which shows on the chart the current in amperes delivered to the different electrolytic systems. It suffices as a check on the night forces so that the required amperes are kept on the tanks. It is also used for determining the commercial efficiency each week on the different systems.

While these features of the equipment are considered by the older men in the service as "frills" and entirely unnecessary, they have the advantage of showing up the weak points in the operation, which more often efforts are made to cover up.

The motor panels are fed by separate circuits from the main switchboard in the basement. The circuits are run so as not to be seen except at the point of entrance to the room either in the attic or in conduits under the floor. No pipes, either for steam or water, or wires are strung overhead, all being safely protected from acid fumes, as will be seen by close inspection of the photographs of the different rooms.

The terminal leads from the generators to the board are lead-covered, paper-insulated cables with a carrying capacity of 25 per cent overload. The leads are bracketed to the wall, as shown by the photographs of the back of the board, Fig. 8. The connections are specially designed heavy copper lugs. The cables to the tank room run through a pitched conduit under the floor and come up to the tank connections through the middle of the enamel brick supports to specially designed lugs which are enclosed in stone slab boxes, 6 in. each way, and filled with beeswax and rosin. This is poured in hot and forms a perfect insulation from the acid of the electrolyte in case of a "spill."

The return cables are equipped with the same kind of box and lug arrangements. The lugs connect to 4-in. x 8-in. copper busbars, into which the necessary individual connections for the tanks are made.

The 30 gold tanks are connected in series in two sets of 15 each, 500 amp passing through each set. For the 12 silver tanks a series-parallel connection is used.

The small board for regulating the current to the copper tank, which is shown in the photograph Fig. 9, is enclosed in a glass case and is located on the wall of the tank room close to the copper tanks.

The **laboratory** (Fig. 10) is equipped with the latest apparatus and devices for handling all the work in the refinery, and further enables the chemist in charge to experiment and solve

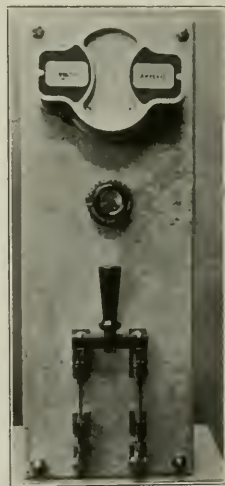


FIG. 9.—COPPER-TANKS BOARD.

the many questions which constantly arise in all electrolytic processes.

A small motor-generator set, giving 50 amp at 2 to 6 volts and a controlling board for electrolytic determinations and experi-

the aid of a portable voltmeter. The tanks in the different systems are numbered consecutively, namely: the gold chloride from 1 to 6, the gold tanks from 1 to 30, the silver tanks from 1 to 12; these numbers correspond to numbered hard-rubber



FIG. 10.—LABORATORY WORK ROOM.

ments, furnishes a very necessary and important piece of apparatus.

The photograph, Fig. 10, gives a good idea of the laboratory workroom, which is separated from the private laboratory and

push buttons on the board. Each system has a separate voltmeter connection. The voltage on any tank is shown by simply pushing the button corresponding to the tank. The button is so constructed that by a turn the contact will remain fixed. In 10 minutes' time the operator can determine the voltages on the three systems, while to determine the voltages by a portable voltmeter would consume at least an hour and two men's time. The workmen have found this board of great advantage in locating short-circuits and irregular workings in the tanks. Over

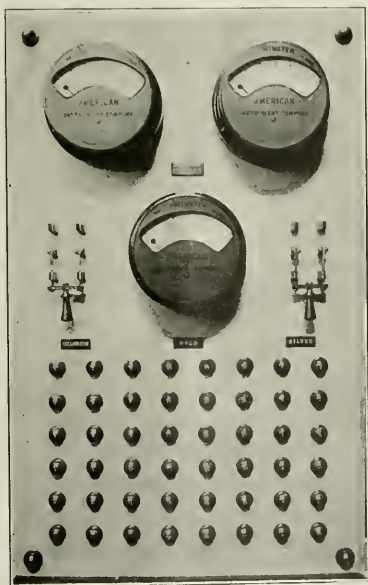


FIG. 11.—TEST BOARD.

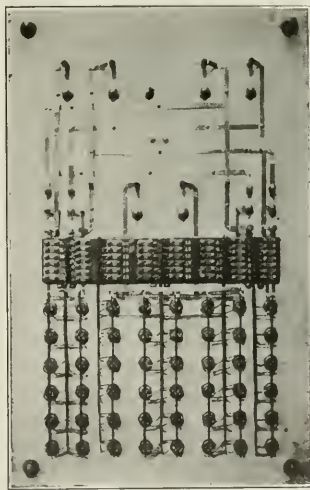


FIG. 12.—BACK OF TEST BOARD.

balance room by a glass partition. In this room is a small test board, shown in Fig. 11, which was specially designed at this mint. The purpose of the board is to quickly determine the voltages on the different tanks in the different systems without

5000 ft. of wire was consumed in making the connections to the different tanks. The photo of the back of the board (Fig. 12) shows the arrangements of connections and contacts.

(To be concluded.)

New Thermit Reactions*

By HANS GOLDSCHMIDT, PH.D.

The object of this paper is to demonstrate some new thermit reactions, the main feature of which is the substitution of other elements or alloys for aluminium in the aluminothermic reaction.

I will first give my definition of a *thermit reaction*: "In a thermit reaction a metallic compound is reduced by one or several metals or metallic alloys in such a way that when the mixture is ignited at one place, the reaction continues to go on spontaneously with complete oxidation of the reducing element, a fluid slag being formed, while the reduced metal is obtained as a compact uniform regulus; if the oxide is used in excess, the reduced metal is free, or practically free, from the element used as reducing agent."

This definition seems lengthy, but it emphasizes two features which are most important from an engineering standpoint—namely, the production of a fluid slag and a uniform, compact regulus of metal.

As is well known, thermit reactions are being employed on a large commercial scale for the production of chromium, manganese, molybdenum, etc., but especially for getting technically pure iron, free from aluminium and carbon, in a fused and exceedingly hot condition for welding and repairing purposes. Since the introduction of the thermit rail-welding process several years ago some 200,000 joints have been made by this method.

At the International Congress for Applied Chemistry in 1903 I discussed the possibility of employing metallic silicon (made in the electric furnace) as a substitute for aluminium in the thermit reaction. I showed that silicon cannot be successfully used in this way. For instance, if a mixture of equivalent parts of silicon and Cr_2O_3 or Mn_2O_3 is ignited, the reaction will not proceed. With a mixture of MnO_2 and silicon it is possible to obtain a reaction similar to the thermit reaction, but, however large an excess of MnO_2 may be employed, it is impossible to eliminate the silicon. Some per cent of silicon will always be found in the manganese.

With ferric oxide (Fe_2O_3) the reaction, when once started, will continue slowly if the silicon is used in a very finely divided state, while with Fe_3O_4 (as used in ordinary thermit) no reaction is obtained with silicon.

It is possible to reduce lead and copper by means of silicon from mixtures of silicon with oxides of lead or copper, but these reactions have hardly any practical interest. In the case of copper, the reaction is relatively slow and the slag contains white globules of a copper silicide with about 10 per cent of silicon; a small quantity of pure copper is also produced. The lead reaction is similar; it proceeds with a strong development of smoke.

If, however, a mixture of equal parts of CuO and PbO with Si is treated, the reaction proceeds properly. The reaction of such a mixture is similar to that of thermit, although it is much slower. A compact regulus is obtained with a fluid slag. The metal is obtained in two layers, the lower of which is an alloy of equal parts of Pb and Cu, with traces of Si, while the upper layer consists of brittle copper with about 10 per cent of silicon and small quantities of lead.

As far as I know, Prof. Muthmann, in Munich, was the first who successfully carried out a new reaction similar to the aluminothermic reaction. Several years ago he showed me in his laboratory a sample of pure regiline vanadium which he had produced by means of his so-called nixed metal (Mischmetall) which consists essentially of metallic cerium. (See the paper of W. Muthmann and L. Weiss on metallic vanadium, niobium and tantalum, published in May, 1907, in Liebig's *Annalen*, vol. 355.)

When the Bitterfelde works placed metallic calcium on the market (made by the electrolytic process described by Dr.

Rathenau; see this journal, Vol. II, page 276, and Vol. III, page 80), the application of calcium in thermit reactions naturally suggested itself. The first publication of experiments in this field appeared in the *Berichte der Deutschen Chemischen Gesellschaft*, Vol. 38, page 924, 1905, containing a preliminary notice by Ernst Beckmann on "some applications of metallic calcium." He states that calcium finely divided and used according to the Goldschmidt process, reduces certain metallic oxides and sulphides "with good success" to metal (for instance, manganese, copper, lead). I have carried out the reactions in my laboratory and I agree, in general, with Mr. Beckmann, although the meaning of his words "with good success" should be further interpreted. It seems that in this respect the opinions of the theorist and of the engineer clash.

In the above definition of a thermit reaction I emphasized the production of a fluid slag and of a uniform, compact regulus. But this is impossible with metallic calcium, according to my extended investigations and experiments. The reason is not far to seek. The calcium oxide formed is but slightly fluid, and although a certain number of small metallic reguli are obtained (for instance, in the reduction of iron oxide), yet a large part, and generally the major part, of the reduced metal is closely intermixed with the slag. This is a serious matter from the standpoint of the engineer, since on account of this "unclean" reaction its practical application for the production of metals or for welding purposes appears impossible.

I will now describe a series* of novel reactions which fulfil all the requirements of the thermit reaction summed up in the above definition.

Calcium-Silicon.

To those experienced in thermit reactions it may appear natural to try to use calcium together with silicon for two reasons. The first is to produce an easily fluid calcium silicate slag. The second to combine the exceedingly turbulent calcium reaction with the slow silicon reaction in such a manner that a medium speed of reaction, best suitable for technical purposes, is obtained.

For a number of years I have carried out several hundred of such thermit reactions which are all more or less of interest to the thermit specialist. These investigations have been carried out by me jointly with Dr. Weil and his assistant, Dr. Müller. Since all these reactions are rapid, it is desirable that more than two eyes observe them. This paper is restricted, however, to a description of the most characteristic reactions only, and of their principle.

Magnesium-silicon acts in a similar way as calcium-silicon and a third suitable combination is a mixture or an alloy of calcium and aluminium.

The engineering value of a thermit reaction depends not only on the calorific effect, but also on the reaction velocity. Naturally, for metal reduction it does not matter how much time the reduction takes, provided the slag is sufficiently fluid and the metal has a sufficiently low melting point to flow together and form a compact regulus below the slag. If, however, a thermit reaction is to be used for welding, the reaction velocity is of considerable importance. If the reaction is slow, the reduced metal cools quickly and cannot be employed for welding. On the other hand, it is evident that a violent reaction, such as is obtained with pure calcium, cannot be made use of in practice.

I will now demonstrate a number of thermit reactions:*

4 Ca + Fe_3O_4 .—The calcium reaction is very violent. It does not yield a compact, uniform regulus of iron. The product is an intimate mixture of small metallic globules and slag.

2 Si + Fe_3O_4 .—This mixture cannot be made to yield a reaction which will go on satisfactorily.

Calcium-silicon thermit.—This reaction goes on almost in the same manner as the ordinary aluminium-thermit reaction, there-

*A lecture held at the Vienna meeting of the German Bunsen Society, May 30.

*These reactions were demonstrated experimentally by Dr. Goldschmidt before the Bunsen Society.

being hardly any evident difference, except that with the silicon-calcium thermit the slag is much more fluid and does not solidify as quickly as the corundum slag of the aluminothermic reaction. This is especially the case when the process is carried out with large quantities.

Naturally, the proportion of calcium to silicon has some effect on the result. A mixture containing equal quantities of Ca-thermit and Si-thermit (so that the active metals Ca and Si are in the proportion of about 2 to 1) is especially effective. This mixture yields a thinly fluid slag, a good metallic regulus and a comparatively high thermic effect.

In the calorimeter this calcium-silicon thermit evolves 720 calories, while the ordinary aluminium thermit evolves about 100 calories more. These figures are approximate and comparative figures only, and are not given as absolutely accurate.

If more calcium is used, than corresponds to the above proportion, the reaction becomes quicker and more violent, while the slag is less fluid. If, on the other hand, the proportion of the silicon is increased, the reaction is retarded.

Of course, the active mixture may be prepared by mixing the proper quantities of calcium shavings or filings with silicon. It is also possible to melt together metallic calcium and silicon under a suitable protective cover; the brittle alloy which is thus obtained, is then powdered, if it does not disintegrate to powder spontaneously.

However, these methods of preparing the calcium-silicon are costly, since metallic calcium made by electrolysis is not inexpensive. On the other hand, metallic silicon can be made in the electric furnace at very low expense. It is possible to buy the kilogram of silicon new for 1 franc (about 20 cents), and if more applications could be found for silicon, the price could be reduced still further.

Moissan and Dilthey (*Berichte der Deutschen Chemischen Gesellschaft*, Vol. 35, page 1106) heated silicon mixed with lime in an electric furnace to a high temperature and produced a calcium-silicide which always contained CaO. Moissan (*Comptes Rendus*, Vol. 127, page 584) obtained a calcium silicide with some 20 per cent calcium and a considerable quantity of carbon.

I have succeeded in making a calcium-silicide containing more than one-third of metallic calcium, without making use of the electric furnace. (Concerning the properties of this calcium-silicide and its application for the purification of metals, especially steel, see the June issue of this journal, page 244.)

Magnesium-Silicon.

$4\text{Mg} + \text{Fe}_2\text{O}_3$.—Magnesium thermit reacts like calcium thermit, while a mixture of magnesium and silicon gives a reaction similar to ordinary thermit. Concerning investigations by Clemens Winkler in this field, more than 18 years ago, see *Liebig's Annalen*, Vol. 301, page 1971, also *Berichte*, 1800, Vol. 23, pages 44, 120, and *Journal für Praktische Chemie*, 1864, 91, 199.

Naturally there are certain proportions between Mg and Si which are especially suitable for a thermit reaction, but it is possible to vary this proportion within even wider limits than in the case of calcium and silicon.

Equal portions of the magnesium-thermit and silicon-thermit, containing about 60 parts of magnesium and 40 parts of silicon as active metals, yield a good thermit reaction which evolves approximately as many calories as ordinary aluminium-thermit. However, these magnesium-silicon reactions have certain practical disadvantages which render them less suitable in practice than the aluminium-thermit reaction.

The production of magnesium-silicide, like that of calcium-silicide, has not yet been successfully carried out. Silicon acts on magnesium not as forcibly as on lime. A higher temperature is necessary, which results in the evaporation of magnesium from the alloy so that the final product contains a smaller quantity of magnesium in comparison with the content of calcium in my calcium-silicide.

It is similar with BaO and SrO. We succeeded in preparing a 40 per cent barium silicide at a comparatively low temperature, while the action of Si and SrO could not be established with certainty for reasons similar to the case of MgO.

Aluminium-Calcium.

In a third reaction aluminium is used together with calcium. In this case we have two elements, each of which gives a rapid reaction. It was, therefore, to be expected that under certain conditions the aluminium reaction can be strengthened by calcium. Experiments have confirmed this conclusion to some extent. The formation of an easily fusible calcium-aluminate slag is especially advantageous.

Calcium may be mixed with aluminium within very wide limits. Of course, too high a calcium content is to be avoided, while too small a calcium content has no effect.

An especially good proportion is a mixture of 40 parts of calcium thermit to 60 parts of aluminium thermit. The ratio of calcium to aluminium is about 53 to 47. The aluminate slag formed has the composition $3\text{CaO} - 2\text{Al}_2\text{O}_3$ and is very fluid. In the calorimeter this thermit shows an even higher heat effect than aluminium-thermit, namely, 880 calories.

With this calcium-aluminium thermit it is possible to carry out very nicely a number of metallic reductions. The reduction of chromium from chromic oxide succeeds very well. Compact reguli of chromium are obtained even from small quantities of pure chromic oxide, while with aluminium as reducing agent this is possible only if a certain amount of chromic acid is added to the chromic oxide.

The calcium-aluminium may be made either by melting the two elements together, if it is not preferred to use the calcium separately, or by electrolytic deposition of calcium on an aluminium cathode according to the patent of Poulenc. (See also United States Patent 875,606, application filed July 7, 1902, granted on Dec. 31, 1907.)

* * *

The question whether it is preferable to replace part of the aluminium in thermit by calcium is simply one of cost. Since 1 kg of aluminium combines with about the same quantity of oxygen, while 1 kg of calcium combines only with 0.4 kg of oxygen, the conditions are not very favorable. Metallic calcium must become considerably cheaper if there shall be any advantage in practice in replacing a small portion only of aluminium by calcium.

The use of magnesium was patented by me 10 years ago, but it has the practical disadvantage that magnesium cannot be made as cheaply as aluminium. For practical use in thermit this would be necessary since magnesium combines with less oxygen than aluminium.

The conditions are different with a mixture of silicon and magnesium or calcium. In this case the conditions are more favorable to magnesium since it combines with more oxygen than calcium. But calcium has the advantage that it can be made together with silicon at a relatively low expense. Nevertheless the practical result is not the same as with aluminium nor is the calorific effect the same, so that for the present most of these reactions are of more theoretical interest.

In each of these three reactions (calcium-silicon, magnesium-silicon and aluminium-calcium) the best results are obtained, if the composition is proportioned so that the slag becomes as fluid as possible.

For calcium-silicon, the most fluid calcium silicate slag is $4\text{CaO}, 3\text{SiO}_2$, with a melting point of 1425°C . (Boudouard, *Iron and Steel*, 1905, page 352). This corresponds to a thermit in which the active metals form an alloy of 67 per cent Ca and 33 per cent Si, or are mixed in this proportion.

A similar result is obtained with a magnesium-silicon thermit containing 60 per cent of Mg and 40 per cent of Si. The slag has the composition $7\text{MgO}, 4\text{SiO}_2$, with about the same melting point as $4\text{CaO}, 3\text{SiO}_2$.

A mixture of about equal parts of aluminium-thermit and

calcium-thermit (the proportion of calcium to aluminium being 63 to 67), gives a slag of the composition 2CaO , Al_2O_3 , with a melting point of 1400°C .

Slightly lower is the melting point of the slag 3CaO , $2\text{Al}_2\text{O}_3$, namely, 1395°C . This is formed from the reaction of a mixture of 40 per cent calcium-thermit and 60 per cent aluminium-thermit (Ca to Al = 53 to 47). See Boudouard, page 354.

It is certainly interesting to see that the constituent elements of the most abundant materials on earth, namely, aluminium, silicon and magnesium, yield the best thermit reactions, producing a high temperature and an extraordinary energy density, due to the high velocity of the reaction.

Dr. O. P. Watts and Mr. J. M. Breckenridge, at the last annual meeting of the American Electrochemical Society, have presented a paper in which they also deal with the possibilities of replacing aluminium in the aluminothermic reaction by other active metals, like calcium, magnesium and silicon. While in my researches I always had in view the technical applications, the investigation of Watts and Breckenridge is perhaps more of a scientific interest. I may say that until the publication of the report of this paper (this journal, June, 1908, page 237) I did not know of this investigation. This is, therefore, a case of two parallel independent researches leading to similar results. Messrs. Watts and Breckenridge refer in their paper to the patents which have been issued to me in the meanwhile.

Cold-Junction Temperature Corrections of Pt. Pt Rh and Pt. Pt Ir Thermo-Electric Pyrometers.

By CORNELIS OFFERHAUS AND ERNST H. FISCHER.

Thermocouples are extensively used in measuring high temperatures. The junction of two metals, of two alloys of different concentration or composition, or of a metal and an alloy is the seat of an e.m.f., the magnitude of which depends upon the temperature of the junction.

A practical arrangement for measuring temperatures by means of a thermocouple consists of connecting two wires of a different composition, as stated above, by twisting, or better soldering, them together, and placing the junction at the place the temperature of which is to be measured. This is called the hot-junction. The other ends (the so-called cold-junction) are connected by means of copper wire leads to a galvanometer of comparatively high resistance, so that the voltage drop in the couple will be small and the change in resistance of the couple, in heating it, negligible in comparison with the total resistance of the circuit. (See Fig. 1.)

The current which flows through the wires and which is measured by the galvanometer, is then a function of the difference of temperature between the hot and the cold junction. The temperature of the cold junction should not differ much from the temperature of the galvanometer; that is, the temperature of the cold circuit should be as uniform as possible.

Le Chatelier showed that but few metals are suitable for use as thermoelectric pyrometers and recommends as a result of an extensive investigation a couple of Pt and an alloy of Pt with 10 per cent Rh. Heraeus, in Hanau a/M, have such couples of very homogeneous wires on the market, and Siemens & Halske have under the millivolt scale of their galvanometer, especially constructed for the purpose, a temperature scale to be used with such a couple.

Besides Pt. Pt Rh couples with 10 per cent Rh, there are on the market couples of other concentrations, and, although Pt Rh-alloys have certain advantages over Pt. Ir alloys, Pt. Pt Ir couples are used.

Before using a couple it must be calibrated. In doing this the cold junction is kept at a constant temperature of 0°C . The hot junction is placed in the vapors of chemically pure substances of known boiling points and in molten chemically pure substances of known melting points and the constant e.m.f. produced is read. A calibration curve is plotted with the e.m.f. as abscissa and the temperature as ordinate.

The couple may also be calibrated by comparing it with a standard couple, which has already been calibrated as described above. Comparison with a gas-thermometer is not practical.

For high temperatures the calibration curve of Pt. Pt Rh and Pt. Pt Ir. couples deviates but slightly from a straight line and is well represented above 250°C by the following logarithmical formula derived by Holman.

$$\log e = a \log t + b$$

in which e is the e.m.f. (preferably in microvolts); t , the temperature, to be measured in degrees C., and a and b are two constant factors, depending mainly upon the composition of the couples. For the lower range of temperatures, portions of the curve are well expressed by a parabolic formula.

In using the calibrated couple to measure temperatures, the temperature of the cold junction may be kept at 0°C , e. g., the temperature at which it was calibrated, thus avoiding a cold-junction correction. The temperature which corresponds to the millivolts read is then the true temperature.

It is, however, easier and theoretically more correct to keep the temperature of the cold junction as nearly the temperature of the room as possible. This is accomplished by placing it in a waterbath of sufficient size to maintain more or less a constant temperature.

In using this arrangement, before connecting the galvanometer in the circuit, its needle may be placed at the millivolt corresponding to the temperature of the cold junction as read at the thermometer placed in the waterbath; in this way subsequent correction for the temperature of the cold junction is avoided.

The temperature of the room, and that of the cold junction, may change during a given operation and it will, therefore, be more correct to start with the needle at zero and to correct for the temperature of the cold junction, the two readings, e. g., galvanometer and thermometer reading, being taken simultaneously.

The current indicated by our instrument is a measure of the difference in temperature between the hot and the cold junctions. The true temperature of the hot junction is, therefore, if we start with the needle at zero (the cold junction having the temperature of the room), not the temperature which corresponds to the millivolt reading, but the true temperature is found by adding the number of millivolts, which corresponds to the temperature of the cold junction, to the millivolt reading. That this way of operating is correct is shown by Table I, which contains experimental data and which is self-explanatory.

Adding the temperature of the cold junction to the temperature corresponding to the millivolt reading, or to the temperature read directly from the temperature scale, is not permissible, unless we multiply this temperature by a certain correction-factor which is smaller than unity. R. Vogel (*Zeit. f. Anorg. Chem.*, 1905, 45) seems to have been the first who calculated and applied correction factors for the temperature of the cold junction in reading in this way. The correction factor comes in because the relation of e.m.f. and the temperature is not a straight line.

This relation, and the correction factor in consequence, changes with the composition of the couple, and the correction factor for each couple changes furthermore with the temperature of its hot junction and also with the temperature of its cold junction. It should be pointed out that the correction factors indicated by Vogel are calculated from an Heraeus Pt. Pt Rh (10 per cent) couple and a cold junction of about 50°C . and that they hold good only for this couple.

As the last method for reading with or without applying a correction factor for the temperature of the cold junction is in general use, it will be of interest to show just how much this correction factor for the temperature of the cold junction is influenced by the composition of the couple and how it changes for each couple with the temperature of the hot and cold junctions.

For this purpose five different couples, all of which are on

the market, and sold as thermoelectric pyrometers, were calibrated. The couple marked No. 1 is the Heraeus Pt. Pt Rh (10 per cent) couple; No. 2 is a couple from Belais & Cohn, New York, and sold as Pt. Pt Ir (3 per cent). No. 3 is a Pt. Pt Rh couple from the Cambridge Scientific Instrument Co., Ltd., England; No. 4 is a couple from Belais & Cohn, New York, and sold as Pt. Pt Ir (10 per cent); No. 5 is a Pt. Pt Ir couple from the Cambridge Scientific Instrument Co., Ltd., England.

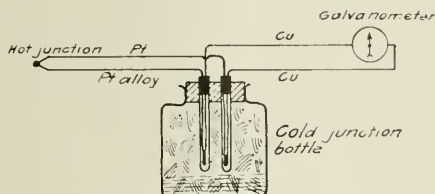


FIG. 1.—CONNECTIONS OF PYROMETER.

The cold junction was kept at a constant temperature (0° C.) and the boiling points of water, naphthalene (218° C.), sulphur (445° C.), and the solidification points of pure antimony (631° C.) and copper (1084° C.) were taken as constant temperatures. The arrangement described before (Cu—Pt—Pt. alloy—Cu), and shown by Fig. 1, was used.

In this arrangement there is no true cold junction, but a cold circuit. An arrangement with a true cold junction (Cu—Pt—Pt. alloy—Pt—Cu) for which one more Pt-wire is required and which is shown in Fig. 2, gives exactly the same figures as were found repeatedly by experiment (the temperature of the cold junction was 0° C.).

It is practically sufficient that the temperature of the connections of the Pt- and Pt-alloy wire with the copper leads be uniform, although it is better that the temperature of the entire cold-circuit be uniform. In using ice in the bath for the cold junction, the temperature of the cold junction was found to be not 0° C. but 2° C., and so in order to have the cold junction at 0° C. the tubes of the cold-junction bottle (see Fig. 1) were filled with ice.

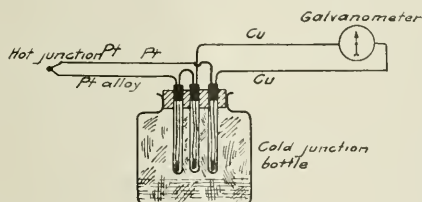


FIG. 2.—CONNECTIONS OF PYROMETER.

In taking the cooling curve of antimony it is necessary to stir it a short time before and during the solidification. Antimony shows, as is known, the phenomena of undercooling, and if considerable undercooling takes place, the temperature will not quite reach the melting point. In taking cooling curves of copper, pure hydrogen-cooled shot-copper in a graphite crucible was used; the metal was kept well covered with charcoal. In order to get the true sharp solidification point we recommend poling the melted copper as well with small sticks of wood. By doing this, very constant points were obtained, generally some what higher than when omitting this operation.

From the data obtained curves were plotted, which are shown in Fig. 3. Logarithmical formulae were calculated, which were based on the constants of sulphur and copper, found by experiment. These formulae are used from 100° C. up. Between 0° C. and 100° C. a parabolic formula of two terms was derived and used in subsequent calculations. It was found that the

functions applied between these ranges agreed best with the relation found by experiment. They contain few terms, making the work of computation a minimum. Table II gives the formulae found for the different couples, and Table III shows temperatures calculated with the logarithmic formula and the true temperatures for couple No. 2 and No. 4.

Table IV contains the correction factors for the five couples under discussion, calculated with these formulae for a hot junction temperature of 0° C., e. g., a temperature near 0° C., and different temperatures of the hot junction from 100° up to 1100° C. in intervals of 100° C.

Table V contains the correction factor for one of these couples (No. 2) calculated for the same temperature of the hot junction as before, but a variable temperature of the cold junction.

A concrete example may show the method used in calculating. In Table IV it is seen that the correction factor for a temperature of the cold junction near 0° C. in using couple No. 2 is 0.55 for a hot junction of 700° C.

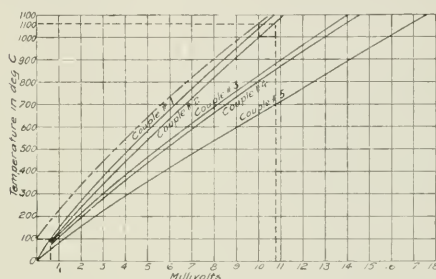


FIG. 3.—CURVES OF RESULTS.

The lower part of the calibration curve of this couple is well represented by the formula:

$$E = 5.9115 + 0.0178 t^2$$

The tangent is: $\frac{dE}{dt} = 5.9115 + 0.0178 t = 5.9115$ for $t = 0^{\circ}$ C.

The upper part of the same curve is well represented by the formula:

$$\log e = 1.1116 \log t + 0.6657$$

$$\text{or } \log e - \log x = 1.1116 \log t$$

$$\text{hence } e = x \times t^{1.1116}$$

hence: $\frac{dc}{dt} = 1.1116 \times x \times t^{0.1116} = 10.512$ for $t = 700^{\circ}$ C.

The ratio of the tangent at different temperatures to the tangent at 0° C. gives their correction factors if the temperature of the cold junction is near 0° C. The correction factor for the temperature of the hot junction of 700° C., the cold junction being near 0° C., is, therefore:

$$\frac{5.9115}{10.512} = 0.55 \text{ (28).}$$

The couples are calibrated and the formulas derived with a cold junction of 0° C. Only the correction factors for temperatures of the cold junction which are near 0° C. can, therefore, be calculated in this way. The factors for other temperatures of the cold junction are calculated as follows:

To find the correction factor of couple No. 2, for a hot junction of 1000° C., the cold junction being 100° C., insert $t = 1000$ in the logarithmic formula and solve for e (see also Fig. 3).

$$\log e = 1.1116 \log 1000 + 0.6657$$

$$e = 10012.$$

Add 760 microvolts, which correspond to 100° C., insert the sum = 10772 microvolts in the same equation and solve for t :

$$\log 10772 = 1.1116 \log t + 0.6657$$

$$t = 1068.1.$$

The correction factor is then:

$$\frac{68.1}{100} = 0.68 \text{ (1.)}$$

The correction factor can also be found graphically. In mov-

TABLE I
COUPLE No. 1.
Temperature of Hot Junction.

Temp. of Cold Junction.	100°	Diff.	218°	Diff.	445°	Diff.	631.5°	Diff.	1084°
0°	0.76mv	1.07	1.83mv	2.24	4.07mv	1.82	5.89mv	5.05	10.94mv
Diff.	0.69	...	0.99	...	0.68	...	0.11	...	0.07
17.5°	0.67mv	1.07	1.74mv	2.25	3.99mv	1.79	5.78mv	5.09	10.87mv
Diff.	0.09	...	0.08	...	0.09	...	0.11	...	0.14
30°	0.58mv	1.08	1.66mv	2.24	3.90mv	1.77	5.67mv	5.06	10.73mv
Diff.	...	...	0.49	...	0.51	...	0.54	...	0.53
100°	0.0mv	...	1.17mv	2.22	3.39mv	1.74	5.13mv	5.07	10.20mv
Diff.	...	...	...	...	1.11	...	1.06	...	1.09
218°	...	...	0.0mv	2.28	2.28mv	1.79	4.07mv	5.04	9.11mv

TABLE II

Couple No. 1.	$\log e = 1.1890 \log t + 0.41527$	$e = 3.85$	$t = 0.0284 t^2$
Couple No. 2.	$\log e = 1.1116 \log t + 0.6657$	$e = 9.915$	$t = 0.0778 t^2$
		(between 0° and 50°)	
Couple No. 3.	$\log e = 1.1893 \log t + 0.526$	$e = 5.90$	$t = 0.0213 t^2$
Couple No. 4.	$\log e = 1.1534 \log t + 0.6538$	$e = 7.923$	$t = 0.0158 t^2$
Couple No. 5.	$\log e = 1.1021 \log t + 0.895$	$e = 11.97$	$t = 0.0059 t^2$

TABLE III.

Couple No. 2.	$\log e = 1.1116 \log t + 0.6657$	Couple No. 4.	$\log e = 1.1534 \log t + 0.6538$
	calculated Diff.		calculated Diff.
H ₂ O 100°	98.3° (1.7)	H ₂ O 100°	103.5° (3.5)
Naphthalene 218°	216.8° (1.2)	Naphthalene 218°	218.9° (0.9)
Sulphur 445°	(445)°	Sulphur 445°	(445)°
Sb 631.5°	630° (1.5)	Sb 631.5°	620.7° (11.5)
Cu 1084°	(1084)°	Cu 1084°	(1084)°

TABLE IV.

Temp./ture Hot Junc'n.	Corr. Fact. Couple No. 1.	Corr. Fact. Couple No. 2.	Corr. Fact. Couple No. 3.	Corr. Fact. Couple No. 4.	Corr. Fact. Couple No. 5.
100°	0.52(3)	0.68(7)	0.61(8)	0.75(2)	0.86(4)
200°	0.45(8)	0.63(6)	0.54(2)	0.67(5)	0.80(5)
300°	0.42(5)	0.60(8)	0.50(2)	0.63(3)	0.77(3)
400°	0.40(2)	0.58(8)	0.47(5)	0.60(5)	0.75(0)
500°	0.38(5)	0.57(4)	0.45(6)	0.58(8)	0.73(3)
600°	0.37(2)	0.56(2)	0.44(0)	0.57(1)	0.72(0)
700°	0.36(2)	0.55(3)	0.42(7)	0.55(8)	0.70(6)
800°	0.35(3)	0.54(5)	0.41(7)	0.54(6)	0.69(4)
900°	0.34(5)	0.53(7)	0.40(8)	0.53(7)	0.69(1)
1000°	0.33(8)	0.53(1)	0.39(9)	0.52(7)	0.68(3)

TABLE V.

Temperature (Temp. Cold Hot Junc'n.)	Corr. Fact. Couple No. 1.	Corr. Fact. Couple No. 2.	Corr. Fact. Couple No. 3.	Corr. Fact. Couple No. 4.	Corr. Fact. Couple No. 5.
100°	0.68(7)	0.72(2)	0.85	0.83	0.83
200°	0.63(6)	0.67(3)	0.80	0.81	0.81
300°	0.60(8)	0.61(7)	0.77(1)	0.78	0.78
400°	0.58(8)	0.59(4)	0.63(6)	0.74(9)	0.76
500°	0.57(4)	0.58(1)	0.61(6)	0.73(2)	0.75
600°	0.56(2)	0.56(9)	0.60(1)	0.71(8)	0.75
700°	0.55(3)	0.56(2)	0.59(3)	0.70(7)	0.70
800°	0.54(5)	0.55(1)	0.58(2)	0.69(7)	0.68
900°	0.53(7)	0.54(5)	0.57(5)	0.68(8)	0.66
1000°	0.53(1)	0.54(3)	0.57	0.68(1)	0.64
1100°	0.52(6)	0.53(0)	0.56(2)	0.67(3)	0.64

TABLE VI.
CORRECTION FACTORS.

Couple 1.	Temperature of Hot Junction.	Couple 5.	Temperature of Hot Junction.
	400°		400°
15°	0.44(6)	0.36	0.75(8)
30°	0.49	0.40(5)	0.75(8)
50°	0.54(5)	0.45(4)	0.76(3)
100°	0.58(2)	0.58(2)	0.60(2)

ing the calibration curve (which represents the relation between e.m.f. and the temperature for a cold junction of 0° C.) to the left, parallel to the abscissa for a distance equal to the microvolts corresponding to the temperature of the cold junction, the curve obtained is the calibration curve for the same couple with a cold junction of the temperature in question. This is confirmed by Table I.

The vertical distance of any point of the original calibration curve to this new curve divided by the temperature of the cold junction is the correction factor for this particular point. Fig. 3 explains this and Table V gives the correction factors with a cold junction of 100° C., both as calculated and as found graphically.

From the form of the curves it can be seen that the magnitude of the correction factors decreases with the increasing temperature of the cold junction.

Table V and Table VI give a quantitative idea of the influence of the temperature of the cold junction on the magnitude

of the correction factor. Table VI shows that this influence is greater for the Pt—Pt Rh than for the Pt—Pt Ir couples.

Siemens & Halske prescribe in a pamphlet on their Le Châtelier thermocouple (Pt—Pt Rh 10 per cent) an invariable correction factor of 0.5 for the temperature of the cold junction, provided this temperature does not exceed 50° C. Vogel uses a variable correction factor for this same couple.

TABLE VII.

ERRORS IN USING AS CORRECTION FACTOR 0.5.

Couple 1.	Temperature of Hot Junction.	Couple 5.	Temperature of Hot Junction.
	400°		400°
15°	0.8°	2.1°	1100°
30°	0.2°	0.2°	0.97%
50°	0.3°	2.85°	7.8°
	0.008%	0.27%	5.7°
	2.25°	2.3°	1.95%
	0.55%	0.21%	13.0°
			9°
			3.75%
			0.85

ERRORS IN USING THE VARIABLE CORRECTION FACTOR OF VOGEL.

Couple 1.	Temperature of Hot Junction.	Couple 5.	Temperature of Hot Junction.
	400°		400°
15°	2.16°	1.8°	1100°
30°	0.84°	0.16°	2.58°
50°	3.0°	2.25°	3.15°
	0.75%	0.2%	0.04%
	2.8°	1.30°	5.1°
	0.56%	0.12%	1.3%
			8.5°
			10.5°
			21%
			0.95%

ERRORS IN USING AS CORRECTION FACTOR 1.

Couple 1.	Temperature of Hot Junction.	Couple 5.	Temperature of Hot Junction.
	400°		400°
15°	8.31°	9.6°	1100°
30°	2.08°	0.87°	4.65°
50°	15.3°	17.85°	0.9%
	3.8%	1.62%	7.2°
	22.75°	27.3°	1.8%
	5.69°	2.48°	12.0°
			3%
			15.5°
			1.4%

Table VII now gives for extreme cases the errors arising in using an invariable correction factor of 0.5, in using Vogel's variable factors (which were calculated for a Pt—Pt Rh (10 per cent) couple and a cold junction of about 50° C.), and in using no correction factors at all, in degrees Celsius and in per cent.

The limit in which it will be permissible to use an invariable correction factor or an average factor, variable with the temperature of the hot junction, for all the couples under discussion, an invariable factor for each couple or a factor, variable with the temperature of the hot junction, for each couple, and the necessity to consider the influence of the temperature of the cold junction on the correction factor, will depend upon the accuracy required in any particular case and can be learned from Table VII.

For accurate measurements we recommend starting with the needle of the galvanometer at 0° C., adding to the millivolt reading the number of millivolts corresponding to the temperature of the cold junction and finding the true temperature from the sum thus obtained. This can be done graphically, in which case it is advisable to plot the part of the curve between 0° C. and 50° C. to a large scale. In calculating we recommend to use a two-term parabolic formula between 0° C. and 50° C., or 0° C. and 100° C., and for the higher temperature range Holman's logarithmic formula based on the boiling point of S and the melting point of copper as constants.

In closing we would like to call attention to the following practical point. The scale of the high-resistance millivoltmeters of Siemens & Halske (0—18 mv) and Kayser & Schmidt (0—16 mv) will not measure high temperatures with a high-current couple as e. g. couple No. 5. In such a case the current

may be cut down by putting in outside resistance. The resistance necessary can be calculated from the formula:

$$E_1 (w + w_1) = E w$$

in which E = the voltage reading without outside resistance,

E_1 = the voltage reading with outside resistance,

w = resistance of the instrument,

w_1 = the outside resistance.

The resistance once fixed and the calibration without resistance made, points of the new calibration curve can be calculated with the help of the same formula, e. g., it is not necessary to recalibrate. The high temperatures in question are found by extrapolation.

Electrodeposition of Nickel.

DR. EDWARD F. KERN and MR. FRANCIS G. FABIAN have published in the July issue of the *School of Mines Quarterly* an extensive report on an investigation carried out at Columbia University on the electrolytic deposition of nickel.

The authors first give abstracts from literature on the electrodeposition of nickel and sum up the results of former work as follows:

The electrolyte generally used for **electroplating** is a solution of nickel-ammonium sulphate, which may be neutral, or else slightly acid with a weak acid such as boric, phosphoric, benzoic, acetic, tannic, tartaric or citric; it may also contain alkali salts of these acids. The acid is added for the purpose of dissolving basic salts of nickel, which are the result of oxidation. An excess of acid causes evolution of hydrogen which produces spongy or non-adherent deposits.

Electrolytes containing nickel-ammonium phosphate are used to less extent than those containing nickel-ammonium sulphate.

In exceptional cases, electrolytes containing nickel chloride and nickel-potassium cyanide have been used.

The presence of boric acid in nickel electrolytes not only keeps the solution clear, but also causes the formation of a smoother and less brittle deposit than when not present. The amount used runs from 1.5 to 30 grams H_3BO_3 per 100 c.c. solution.

Nickel deposits formed in nickel-ammonium sulphate electrolytes are harder, smoother and more durable than those from chloride electrolytes.

The addition of 5 to 10 grains of sodium chloride per 100 c.c. of nickel-ammonium sulphate electrolyte reduces the e.m.f., and also causes the deposit to form more regular, more adherent and tougher, and the anode to dissolve more uniformly.

Pure nickel anodes are less readily dissolved than those which contain iron, copper, tin, etc., unless the electrolyte contains a chloride.

Rolled sheet anodes are less readily dissolved and require a higher e.m.f. than cast anodes.

Rough cast anodes require less e.m.f. and are more uniformly dissolved than smooth, polished cast anodes, or sheet nickel anodes.

The solutions which are used for **recovering nickel from nickel-copper mattes, or alloys**, are either dilute sulphuric acid or dilute hydrochloric acid. The copper in either solution is reduced below 1 per cent by electrolysis and finally completely removed chemically by cementation on metallic nickel, or else by hydrogen sulphide which is afterwards expelled. The purified solution is rendered alkaline, filtered to remove precipitates and the nickel recovered by electrolysis in suitable cells, using a lead anode for the sulphate solution and a graphite anode for the chloride solution.

The refining of nickel is said to be accomplished in electrolytes of nickel-potassium cyanide, or else of neutral nickel-sodium chloride. The sulphate electrolytes are not so satisfactory as these, as the deposits from sulphate electrolytes contain some sulphur.

There is a difference of opinion as to the cause of **solid, adherent deposits of nickel**; some electrometallurgists claim that the

most satisfactory deposits are from alkaline electrolytes, whereas others say that the electrolyte must be acid. The general opinion, however, is that non-adherent deposits are due to: the electrolyte being too acid, the temperature of electrolyte being too low, or else the cathode is not clean. Pulverulent deposits are due to: too high a current density, too high an e.m.f., and too acid electrolyte.

The formation of insoluble basic salts is prevented by acidifying the electrolyte with a weak acid, such as boric, perchloric, perbromic, or an organic acid, or else with a slight amount of sulphuric or hydrochloric acid.

Conditions which favor solid adherent deposits of nickel are: slightly acid electrolyte, to prevent basic salts; pure electrolyte; gas-free electrolyte; temperature between 40° and 65° C.; constant current density; low e.m.f.; efficient circulation; clean cathode; and concentrated electrolyte.

Concentrated electrolytes, especially those consisting of very soluble nickel salts, give the most satisfactory deposits, other conditions being equally favorable.

The tendency of nickel deposits to curl is greatest with high current density, said to be due to formation of nickel hydride, which is the result of greater liberation of hydrogen with high current density and high e.m.f.

The presence of nitric acid in a nickel electrolyte prevents the formation of solid deposits.

"The idea which is apt to prevail after one has reviewed the literature on the electrolytic refining of nickel is that numerous processes have been suggested, devised and published, but that only a few have gained any degree of technical success. Even the more recent processes possess such disadvantages as large and expensive plants, complex apparatus, and a number of involved operations, which must necessarily entail losses, all of which are quite serious objections."

In passing over to an account of their own researches, Messrs. Kern and Fabian make the general statement that "the conductivity of an electrolyte varies directly as the weight of salt in solution, and the more concentrated the electrolyte, the more satisfactory the deposit. As examples may be cited: lead fluosilicate, silver nitrate, gold chloride, copper fluosilicate, nickel chloride, antimony fluoride, and iron chloride, all of which yield more satisfactory deposits than electrolytes of other salts of the respective metals. Another great advantage gained by using the more soluble salt is lessening the inconvenience due to salts crystallizing and collecting between contacts, and also forming on the electrodes, especially the anode, all of which offers high resistance to the passage of the current." So, before deciding on what salts they would use in the investigation, they looked up the solubilities of the more soluble salts of nickel, which are given in the following table:

Table of Solubilities of Nickel Salts.

Nickel bromide: $NiBr_2$; soluble in water, alcohol and ether.

Nickel chloride: $NiCl_2 \cdot 6H_2O$; easily soluble in water, alcohol and ether. 100 c.c. saturated water solution at 20° C. contains 39 grs. $NiCl_2$. 100 c.c. saturated water solution at 40° C. contains 42 grs. $NiCl_2$.

Nickel iodide: NiI_2 ; easily soluble in water. 100 c.c. saturated solution at 20° C. contains 60 grs. NiI_2 . 100 c.c. saturated solution at 40° C. contains 64 grs. NiI_2 .

Nickel cyanide: $Ni(CN)_2$; insoluble in water. Nickel-potassium cyanide $Ni(CN)_2(KCN)_2$; easily soluble in water, more soluble if KCN is present.

Nickel dithionate: $NiS_2O_8 \cdot 6H_2O$; soluble in 0.897 part water at 12° C.

Nickel-ammonium dithionate: $2NiS_2O_8 \cdot 9(NH_4)_2S_2O_8 \cdot 16.5H_2O$; soluble in water and in an excess of ammonia.

Nickel fluosilicate: $NiSiF_6 \cdot 6H_2O$; easily soluble in water.

Nickel thiosulphate: $NiS_2O_3 \cdot 6H_2O$; permanent, soluble in water.

Nickel sulphate: $NiSO_4 \cdot 7H_2O$; soluble in three parts water at 20° C. Soluble in two parts water at 50° C.

Nickel-ammonium sulphate: $NiSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$; soluble

in 12 parts water at 20° C. Soluble in 5 parts water at 50° C. Nickel-sodium sulphate: $\text{NiSO}_4 \cdot \text{Na}_2\text{SO}_4 \cdot 4\text{H}_2\text{O}$; soluble in 3 parts water at 20° C.

Nickel-potassium sulphate: $\text{NiSO}_4 \cdot \text{K}_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$; soluble in 9 parts water at 20° C.

Nickel phosphates: insoluble in water, soluble in dilute ammonia, and in dilute phosphoric acid.

From this list Messrs. Kern and Fabian selected the following electrolytes to be investigated: nickel dithionate, nickel fluosilicate, nickel chloride, and nickel sulphate, because of their higher solubility and their cheapness of preparation.

While for the full amount of the experiments of the authors reference must be had to the original paper, we will here sum up only the chief results of the investigation. The average data of the different runs made will be seen from the following table:

Composition of the Electrolytes.	Temperature, °C.	C. D. amperes per sq. ft.	Time of run, minutes.	NiCl ₂ Electrolyte.		NiSO ₄ Electrolyte.		NiSiF ₆ Electrolyte.	
				Average e.m.f. in volts.	Cathode current efficiency.	Average e.m.f. in volts.	Cathode current efficiency.	Average e.m.f. in volts.	Cathode current efficiency.
8% nickel & half molecular equivalent of free acid.	20	10	180	0.49	3.20	0.89	0.86	0.96	0.78
	40	10	180	0.36	1.25	0.65	0.62	0.78	1.64
	60	10	180	0.21	1.01	0.42	0.39	0.61	1.80
8% nickel & 1/10 the molecular equivalent of free acid.	20	10	255	0.73	62.6	0.91	1.50	0.82	2.20
	40	10	255	0.52	79.0	0.78	1.60	0.83	4.90
	60	10	255	0.35	71.0	0.51	1.50	0.61	4.80
8% nickel & 1/20 the molecular equivalent of free acid.	20	12	180	0.86	67.2	0.97	0.0	1.02	7.8
	40	12	180	0.53	75.7	0.79	0.7	0.90	7.1
	60	12	180	0.44	80.7	0.61	2.8	0.82	8.5
Neutral solutions containing 8% nickel.	20	10	255	0.78	95.6	1.50	102.2	1.05	92.1
	40	10	255	0.59	99.4	1.35	106.9	0.94	92.4
	60	10	255	0.44	99.2	0.88	101.1	0.73	89.8
Neutral solutions containing 8% nickel.	20	20	480	1.06	91.2	3.45		1.45	96.8
	40	20	480	0.73	94.7	2.30		1.24	100.0
	60	20	480	0.64	88.3	1.40		1.01	90.3
Neutral solutions containing 8% nickel and a half molecular equivalent of sodium salt.	20	20	180	1.02	90.2	3.12	102.2		
	60	60	180	0.58	99.7	0.96	99.8		

In all of the experiments, cast nickel anodes, containing 92 per cent Ni, 5 per cent Fe, carbon and trace of Cu were used. The cathodes were sheet nickel placed one inch from the anodes.

Nickel dithionate is not suitable for nickel electrolytes, as it is decomposed with the separation of sulphur. The e.m.f. required for an electrolyte containing 3 per cent nickel, and at room temperature, was 2.7 volts.

The presence of free acid in nickel chloride, nickel sulphate and nickel fluosilicate electrolytes caused very low cathode efficiency, whereas the anode efficiency was in most cases over 95 per cent. By continued electrolysis the free acid was neutralized and the cathode efficiency increased.

The electrolysis of neutral chloride and fluosilicate solutions with current densities of 10 and 20 amperes per square foot gave very satisfactory deposits, and high current efficiencies. Neutral sulphate solutions were unsatisfactory, as precipitates of insoluble basic salts formed and intermixed with the deposited nickel.

Heating the chloride and the fluosilicate electrolytes decreased the e.m.f., increased the current efficiencies and improved the deposition. The most satisfactory temperature was about 50° C.

During electrolysis of nickel fluosilicate solutions, a small amount of gelatinous silica separated and collected on the bottom of the cells. Heating of these solutions above 75° C. also caused the separation of silica, but very slowly.

A small amount of basic salts separated during electrolysis from the neutral chloride electrolytes, but did not interfere with the deposition. The presence of a small amount of free acid prevented their formation.

On Methods of Obtaining Cooling Curves

By G. K. BURGESS.

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The rôle of thermal analysis in many metallurgical and chemical problems, involving in many instances the constitution and behavior of very complex substances, is of increasing importance; and great advances are being made in our knowledge of the properties of many alloys, minerals and chemical compounds at high temperatures by means of the pyrometer.

Any internal change in the physical or chemical nature of a substance usually alters many of its physical properties, as, for example, its magnetic and thermoelectric behavior, electrical resistance, specific heat, density and microscopic structure. A large internal change at a definite temperature or within a small range of temperature—in other words, "a transformation"—will cause sudden or very rapid changes in some or all of these physical properties, and several of them may be used with advantage in the detection and study of such transformations. In this paper, however, we shall confine ourselves to the consideration of such changes as may be detected, measured and recorded by thermometric means.

METHODS OF THERMAL ANALYSIS.

All methods of thermal analysis are based upon the principle that chemical and physical transformations within a substance are, in general, accompanied by an evolution or absorption of heat. The detection of the temperature and the measurement of the extent of these transformations, and in many cases their interpretation, may be carried out by taking the cooling curve of the substance, which in its simplest form consists in plotting the temperature of the cooling substance against the time.

It is evident that the heating curve of a substance may also be taken to find its characteristics, and this is sometimes done, but in general uniform results are obtained more easily by taking the cooling curve, mainly on account of the greater experimental difficulties in maintaining a uniform rate of heating in the containing furnace. In some problems it is desirable to have both curves, while occasionally, as in transformations involving loss of water of crystallization or of constitution, the heating curves alone are of significance. The same apparatus will evidently serve for both.

The cooling curve, however exactly taken, will, of course, give no indication of those transformations for which there is no evolution or absorption of heat. If the cooling is at constant pressure, as we shall assume in all of what follows, the absence of a transformation—physical or chemical—may be assumed only when both the energy and the volume changes are zero.

The detection of changes in volume, unaccompanied by changes in internal energy, may be effected by the use of an apparatus measuring linear expansion, such as the recording differential dilatometer of Sahmen and Tammann.¹ These cases

¹ Sahmen and Tammann: Über das Auffinden von Umwandlungspunkten mit einem selbst-registrierenden Dilatographen. *Ann. d. Phys.*, 10, p. 879-896; 1903.

are exceptional, however, and we shall not consider them further.

There have been developed a considerable number of methods for obtaining cooling curves which are adapted to the study of recalescence points in steels as well as to the investigation of the composition and properties of alloys and chemical compounds. There has as yet been no general discussion² of the different methods nor of their availability for special problems and it may, therefore, be of some interest to have at hand an outline of the principles of the methods that may be used in obtaining cooling curves as well as a brief mention of the various types of apparatus available, with a discussion of their advantages and limitations.

The methods may be classified in various ways; thus we have to distinguish between those adapted for slow cooling, which is the case most commonly met with, and for very rapid cooling, as in quenching steels; those methods which require an auxiliary body possessing no thermal transformations on cooling, as compared with those requiring only the substance studied; and, finally, we may have, on the one hand, methods involving the time, and, on the other hand, those in which the time may be eliminated. In this paper we have considered in detail only such methods as are adapted for slow cooling and have classified them in terms of the forms of the curves representing the experimental data.

Many operations which can be carried out in the laboratory cannot be applied conveniently in industrial works, so that it will be necessary also to distinguish the various types of apparatus as regards their adaptability either for purely scientific researches or for industrial needs. For the latter, especially, it is very desirable to make all operations as automatic as possible, so that the different methods of autographic and photographic recording should be considered.

Again, we shall have occasion to point out those methods which are the most advantageous to use when very minute quantities of heat or differences in temperature are to be detected, as, for example, the secondary breaks in the cooling curves of many alloys and of numerous compounds and mixtures. In such cases it becomes necessary to use methods of the highest possible sensitiveness, which usually necessitates the discarding of autographic and photographic recording.

We shall mention those methods which are suitable for taking cooling curves in the range of temperatures up to 1500° C., but much of what is said will apply also to higher temperatures if proper precautions be taken to eliminate the effects upon the measuring apparatus of the electrical conductivity of the materials and contents of the furnace. Although several methods of measuring temperature may be used over most of the range indicated, such as the change of electrical resistance of platinum with temperature and the various optical and radiation pyrometers, we shall confine ourselves to the thermo-electric pyrometer made of the platinum metals as being on the whole the most generally suitable over this range for this kind of work, although undoubtedly particular problems may occur in which the use of some other type of pyrometer is preferable.

Use of the Thermocouple.—It may be recalled that the thermocouple possesses most of the desirable attributes of a temperature indicator. With its insignificant volume it may be introduced into a very small space, and so be used with small samples, and it takes up the temperature of the sample with great promptness. When made of the platinum metals, it is very durable and retains the constancy of its indications in a most satisfactory way, even when subjected to contaminating atmospheres, and after deterioration it may usually be restored to its former condition by glowing.

Temperatures may be obtained by means of a simple form of

galvanometer without any accessories. Such a galvanometer, it is true, indicates electromotive forces, while in general the temperature of a thermojunction is not strictly proportional to the electromotive force generated by it, although such a linear relation, which it is desirable to realize in order to simplify the interpretation of the indications of some types of recording instruments, holds very nearly in the case of the platinum-iridium couple of the composition Pt, 90 Pt—10 Ir.

The following table shows the e.m.f. temperature relation and the e.m.f. in microvolts per degree centigrade (de/dT) for couples composed of a wire of pure platinum joined to one of approximate composition: 90 Pt—10 Rh, 90 Pt—10 Ir, and pure Ni, respectively.

Temp. Cent.	Pt, 90 Pt—10 Rh		Pt, 90 Pt—10 Ir		Pt, Ni	
	e.m.f. Microvolts	de/dT	e.m.f. Microvolts	de/dT	e.m.f. Microvolts	de/dT
300	2,290	9.0	4,080	15.9	7,940	11.8
500	4,160	9.7	7,300	16.7	10,510	14.4
700	6,170	10.48	10,720	17.5	13,670	17.1
900	8,340	11.2	14,300	18.3	17,400	16.7
1,100	10,530	11.9	18,030	19.1	21,640	22.4
1,300	13,070	12.6	21,940	19.9	26,330	25.0
1,500	15,600	13.38	26,010	20.7	....	...

It will be seen that the platinum-iridium couple is nearly twice as sensitive as the platinum-rhodium couple besides having a more nearly linear e.m.f.-temperature curve. The advantages are in part offset, however, by the fact that the iridium couple deteriorates more rapidly and is less constant in its indications.

The platinum-nickel couple, although very sensitive, is less reliable than the others, and the Ni wire soon becomes brittle and breaks. Moreover, the effect of the nickel recalescence point (about 375° C.) has some influence on readings taken in its neighborhood.

There are other thermojunctions, made of alloys of the more refractory base metals, which are much more sensitive than the above and which may be suitable over particular ranges. These couples are usually constructed of wire of considerable diameter and are, therefore, not adapted for work with small samples. For exact work one should make sure of their constancy of indication over the temperature range to be studied.

A more robust and less sensitive indicating instrument may evidently be used with this type of thermocouple, although recently pivot instruments, suitable for use with the platinum couples, have been constructed by Paul, of London, and by the Cambridge Scientific Instrument Company.

Methods of Recording.—Before describing the various methods that have been suggested for the taking of cooling curves, it may be well to consider the ways in which the observations may be recorded. Either the observer may himself read and record the indications of the instruments and discuss the data so obtained, either analytically or graphically; or he may use, if the method and desired precision permit, either an autographic or photographic self-registering instrument, when it may or may not be necessary to make further reductions, depending upon the method used and the interpretations sought.

It is evidently of great advantage to use self-recording apparatus when possible and it then becomes necessary to choose between the photographic type and the autographic.³

The latter possesses the advantage that the experimenter may watch any part of the record and can, therefore, control the operation and at any moment vary the conditions affecting the experiment, whereas with a photographic recording apparatus, as usually constructed, the observer does not know whether or not the experiment is progressing properly until it is finished and he has developed the sensitive plate. The manipulation by the photographic method is usually also more delicate and time-consuming and the adjustment less sure, and the record often requires further graphical interpretation.

The autographic method is in general not adapted for interpreting phenomena taking place within an interval of a few seconds, so that for very rapid cooling it is necessary to employ the photographic method. It is possible to construct the photo-

³ The term *autographic* is here used to designate an instrument which is self recording by any other than photographic means.

² A paper by W. Rosenhain, on "Observations on Recalescence Curves," was read before the London Physical Society, January 24, 1908, an abstract of which indicates he has compared the merits of the "Inverse Rate" and "Differential Methods." The Differential Method has also been studied in detail by Portevin, Notes sur l'Emploi du Galvanomètre Différentiel, Rev. de Métallurgie, 5, p. 295; 1908.

raphic recorder so as to obtain a very considerable range of speeds with the same apparatus, while it is difficult and costly to construct an autographic recorder having more than two speeds.

Temperature-Time Curves.

I. θ vs t .—The simplest method of obtaining a cooling curve is to take simultaneous measurements of the temperature of the cooling substance and of the time, from which a plot

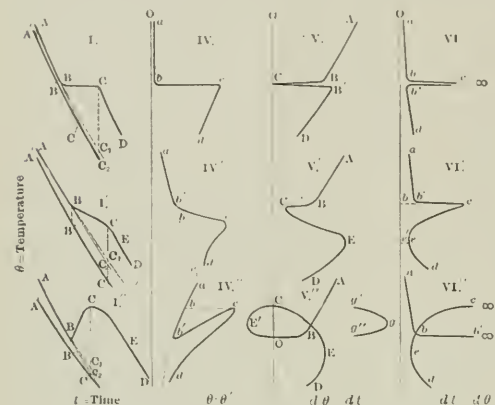


PLATE 1.—TYPES OF COOLING CURVES.

may be made showing the variation of temperature with time. (See Plate I, Fig. 1.)

The most obvious defect of this method is that it will not distinguish between phenomena proper to the substance studied and those due to outside conditions, such as accidental variations in the rate of cooling of the furnace due to air draughts and like causes. Again, where measurements over a considerable range of temperature are to be taken continuously, it becomes impracticable without elaborate experimental arrangements to combine great sensibility with this great range, so that the experimenter is in general forced to choose between great sensibility over a small temperature range or a relatively small sensibility over a large range; and this is especially true if it is desired to record the data automatically.

This method was naturally the first used* and it is to-day perhaps the most common one for taking cooling curves in both metallurgical and chemical laboratories. In its most elementary form it requires a minimum of apparatus—a thermocouple and an indicating galvanometer. Any desired sensibility and range may be had by substituting for the direct-reading galvanometer a potentiometer and a sensitive galvanometer. With this arrangement it is advantageous, when rapidity of observation is an object, to measure the last increment of temperature in terms of the galvanometer deflection rather than try to balance the potentiometer exactly while the temperature is changing.

It is possible in this way to take readings as often as every five seconds with a properly devised, set-up and quick-period galvanometer.[†] A precision of 0.1°C . at 1000°C . may be attained. Independently of the method of measurement used, the certainty of the detection of slight transformations may usually be increased by increasing the size of the sample under observation, thus making available larger quantities of heat.

The constant attention of the observer is, of course, required for either of the above systems of measurement. There have been devised, however, many kinds of self-recording apparatus for using this method, the earlier forms being photographic, while many of the later ones are autographic.

Photographic Recorders.—Among the earliest photographic recorders we may mention the apparatus of Roberts-Austen* (Fig. 1), in which the photographic plate P was given a vertical motion, either by clockwork, or, in order to secure maximum sensibility for several rates of cooling, by means of buoying the plate on water whose rate of flow could be regulated. The

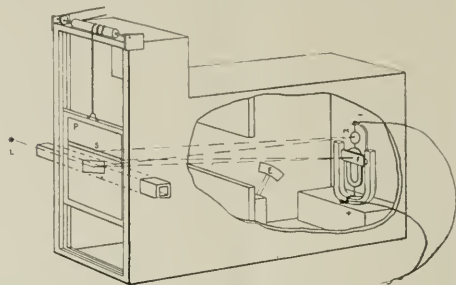


FIG. 1.—ROBERTS-AUSTEN RECORDER.

vertical motion of the plate then gave the time, while the deflection of the galvanometer gave the corresponding temperature, and a beam of light, from the source L, reflected from the galvanometer mirror M, and incident on the plate, after passing through a fine slit S placed horizontally before the moving plate, gave directly on the latter the time-temperature curve.

Light reflected from a fixed mirror F, and interrupted at equal intervals by a pendulum E, gave a fixed zero line as well as a measure of regularity of the motion of the plate. It was the practice later,[†] when taking measurements over short temperature ranges, to increase the sensibility by balancing the greater part of the e.m.f. of the thermocouple with an auxiliary measured e.m.f., and giving the galvanometer the maximum sensibility that would keep its deflections on the plate.

In the apparatus used by Charpy,[‡] or in its very elaborate form as constructed by Toepfer, of Potsdam, for Kurnakow[§] the vertically moving plate is replaced by a rotating cylinder wound with the sensitized paper on which the deflections of the galvanometer are registered. This form of recorder had also been used and discarded by Roberts-Austen.

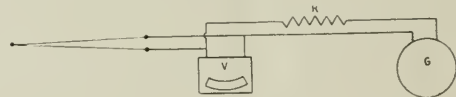


FIG. 2.—SCHMIDT DEVICE.

Kurnakow's apparatus, which must be placed in a dark room, is furnished with an auxiliary telescope and scale system using red light, so that the experiment may be controlled during the taking of a record. As constructed, five speeds may be given to the cylinder; and there is provided an e.m.f. compensating system for maintaining the maximum sensibility over a series of temperature ranges.

There is another device, used by C. L. A. Schmidt,^{||} by which the experiment may be watched while a photographic record of a cooling curve is being taken. It consists in shunting the sensitive photo-recording galvanometer G (Fig. 2) in series with a high resistance R across a direct-reading millivoltmeter V. If the resistance of $R + G$ is great compared with that of V, the readings of the millivoltmeter will not be altered appreciably

*Proc. Royal Society, 40, p. 347; 1891. Nature, 45, p. 534; 1892. First Report of the Alloys Research Committee in Proc. Inst. Mech. Eng., 1891.

†G. Charpy, Bull. de la Soc. pour l'Encouragement, 10, p. 666; 1895. Fourth Report of the Alloys Research Committee, Proc. Inst. Mech. Eng., 1897. A. Stansfield, Phil. Mag., 46, p. 59; 1898.

‡S. Kurnakow, Zeitsch. f. Anorg. Chem., 42, p. 184; 1904

§C. L. A. Schmidt, Chem. Eng., 6, p. 80; 1907.

*Frankenheim; Pogg. Ann. der Physik, 37, 38 (1836; 1837).

†See W. P. White, Potentiometer Installation, Phys. Rev., 25, 334; 1907.

by this operation. Schmidt moves the photographic plate, mounted as in the apparatus of Roberts-Austen, by means of a screw driven by a small motor. In this way any desired speed may be given to the plate.

In practice it has been found difficult to realize conveniently a sufficiently steady motion of the plate in the Roberts-Austen system of recording, and attempts have been made to devise methods in which the photographic plate remains fixed in position. This has been successfully accomplished by Saladin, whose apparatus (Fig. 8) has been modified by Wologdine¹¹ to give the temperature-time curve by removing the prism M and substituting for the second galvanometer G₂ a plane mirror turning about an horizontal axis. This mirror may be controlled by an hydraulic system as in Roberts-Austen's apparatus, or by clock-work as in the model constructed by Pellin, of Paris. The deflection of the galvanometer G₁ gives to the beam of light an horizontal motion over the plate proportional to the temperature, while the vertical motion of the beam of light is given by the mirror turning at a uniform rate and is therefore approximately proportional to the time as registered on a flat plate.

Autographic Recorders.—To obtain a satisfactory autographic or pen record without sacrifice of sensibility of the galvanometer it is necessary to eliminate the friction of the pen or stylus upon the paper. This has been accomplished by the use of mechanisms which cause the pen or stylus at the end of the galvanometer boom to make only momentary contact with the moving paper.¹²

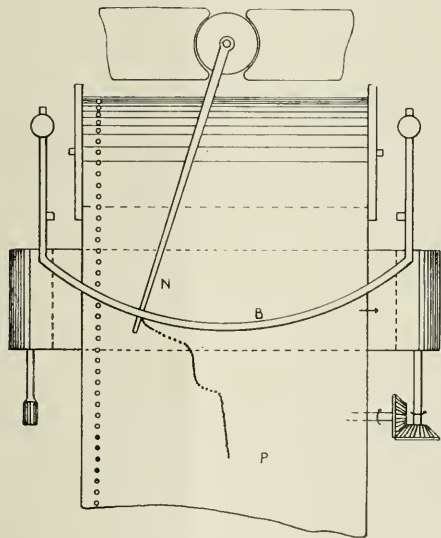


FIG. 3.—SIEMENS & HALSKE INSTRUMENT.

In the Siemens & Halske¹³ form of instrument, Fig. 3, the paper P is driven forward by the same clock-work that controls the pressing down by means of the arm B of the stylus N which imprints dots periodically on the paper by means of a type-writer ribbon running across and beneath the record sheet. This system permits of taking a record continuously over very long periods of time. In most of the other recorders the paper is wound upon a drum, and various devices are used to obtain

the record; thus in the Hartmann and Braun type, a silver stylus makes sulphide dots on a prepared paper; and in the Cambridge thread recorder, rectangular co-ordinates are obtained by having the galvanometer boom strike an inked thread which runs parallel to the drum.

As previously stated, these autographic instruments all give intermittent records and are limited to one or two speeds, and although they may be made very sensitive they are not adapted for the detection of transformations which take place very rapidly, since the recording interval cannot readily be shortened much below 10 seconds, and in most instruments this interval is greater than 15 seconds. In other words they can be used advantageously only for slow cooling.

II. θ vs t , θ' vs t (or θ vs θ').—In order to eliminate the effect of irregularity of outside conditions which influence the rate of cooling, a method commonly used when endeavoring to detect small transformations, consists in placing a second thermocouple in the furnace, but sufficiently removed from the substance studied to be uninfluenced by its behavior. Alternate

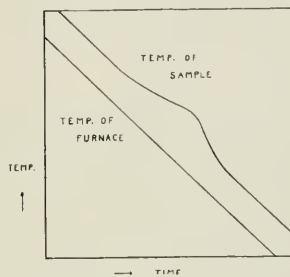


FIG. 4.—CURVE SHEET.

readings on the temperature of the test piece (θ) and of the furnace (θ') are then taken, preferably at definite time intervals. The data are most readily discussed by plotting the two temperature-time curves side by side, as shown in Fig. 4, or by plotting the difference in temperature $\theta - \theta'$ against the temperature θ of the test piece.

This method may be made recording, either by using two instruments or by modifying one of the above mentioned autographic recorders so as to trace the curves of two thermocouples on the same sheet.¹⁴ In practice, however, this method is usually resorted to only when great sensibility is desired, as in detecting minute internal energy changes, when the potentiometer combined with the deflection galvanometer is the most sensitive and quick-working arrangement for taking the measurements. It is convenient to use thermocouples of the same

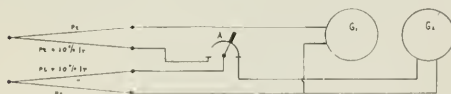


FIG. 5.—DIFFERENTIAL CURVE CONNECTIONS.

composition so as to have readings of both the temperature of the sample and of the furnace given by the same potentiometer setting, and so depend upon the galvanometer deflections for measuring the residual parts of θ and θ' .

Regarding the precision of this method, it is to be noted that the quantity it is really desired to measure is $\theta - \theta'$ in terms of θ , and this is accomplished by measuring θ and θ' , hence the sensibility of $\theta - \theta'$ is no greater than that of θ or θ' . In other words, the method requires the maximum refinement of meas-

¹¹ S. Wologdine, *Rev. de Metallurgie*, 4, p. 552; 1907.

¹² There are a considerable number of thermoelectric recorders; among the manufacturers of these instruments are: Siemens and Halske, Berlin; Hartmann and Braun, Frankfurt a.M.; Pellin, Chauvin and Arnoux, Carpentier; and Richard, Paris; Queen, of Philadelphia; The Scientific Instrument Company, of Cambridge, England, and Rochester, New York; The Bristol Company, Waterbury, Conn.

¹³ *Zeitschr. f. Instrumentenk.*, 24, p. 350; 1904.

¹⁴ The Siemens and Halske instrument has been so arranged. See *Zeitschr. f. Instrumentenk.*, 24, p. 350; 1904.

urement to obtain the quantity sought, as well as the maximum of computation or plotting to reduce the observations.

Differential Curves.

III. θ vs t , $\theta - \theta'$ vs t .—The preceding method II may readily be modified so as to give $\theta - \theta'$, the difference in temperature between the test piece and furnace, by direct measurement instead of by computation, with the added advantage that the precision of $\theta - \theta'$ may be made very great as compared with that of θ , the temperature of the sample. This may be accomplished, for example, by placing a commutator in the thermocouple circuit at A, Fig. 5, so that alternate measurements on θ and $\theta - \theta'$ may be taken in terms of the time. Evidently the connections may be so made that either the galvanometer G_2 of the same direct reading or potentiometer system that measures θ , or a separate instrument G_1 , as shown in the figure, may be used to measure $\theta - \theta'$.

Use of a Neutral Body.—Accidental variations in the indications of the auxiliary thermocouple giving θ' , the furnace temperature, may largely be eliminated by placing this couple within a blank or neutral substance. The material of the neutral body should be such that it undergoes no transformations involving an absorption or evolution of heat within the

use, requiring, for instance, some three or four successive exposures adjusted to the proper adjacent temperature ranges, to take the cooling curve of a steel from $1,100^\circ$ to 200° C.

Most of the recent exact work¹⁶ employing the principle of this method has been done by taking the observations of θ directly on a potentiometer and $\theta - \theta'$ on the same or an auxiliary galvanometer. In this case of direct reading, the simple arrangement of thermocouples indicated in Fig. 5 may advantageously replace Roberts-Austen's (Fig. 6) or the modification shown in Fig. 7, such as used by Carpenter and others, thus dispensing with one thermocouple and the drilling of a second hole in the sample.

This method is evidently capable of attaining maximum sensitiveness, since the galvanometer connected to the differential thermocouple, giving $\theta - \theta'$ vs t , may be made as sensitive as desired independently of the θ vs t system. There is the further advantage that no limits are set to the range of temperatures over which a given precision in $\theta - \theta'$ may be had.

There is, however, a limitation on the certainty of interpretation of results by this method, especially when the rate of cooling is rapid, due to the fact that it is practically impossible to realize the ideal condition of having $\theta - \theta' = \text{a constant}$, or keeping the cooling curves of the test piece and neutral parallel, for temperature intervals within which there are no transformations of the test piece.

The rate of cooling, and hence the value of $\theta - \theta'$, is influenced by several factors, among the most important of which are the mass of each substance—the unknown and the neutral—its specific heat, conductivity, and emissivity, as well as the relative heat capacities of the furnace and enclosed samples. The $\theta - \theta'$ vs t line is, however, always a smooth curve, except for the regions in which there are transformations in the substance under study.

The autographic system of recording may also be used and it is possible to construct an apparatus by means of which both the θ vs t and $\theta - \theta'$ vs t curves shall be recorded simultaneously on the same sheet by the same galvanometer boom. In order to accomplish this we have made use of a Siemens and Halske recording millivoltmeter having a total range of 1.5 millivolts and a resistance of 10.6 ohms.

The e.m.f. generated by the differential thermocouple, proportional to $\theta - \theta'$, is recorded directly by this instrument. 1° C. corresponds to from 16 to 19 microvolts between 300 and $1,100^\circ$ C. for a platinum-iridium couple, or to about 1.8 mm on the record paper. In series with the Pt-Ir thermocouple giving temperatures is a suitable resistance, about 200 ohms in this case, so that the galvanometer boom may be kept within the limits of the paper when recording values of θ .

The circuit is made alternately through the direct and differential thermocouple circuits in series with the recorder by means of a polarized relay actuated by the same battery that depresses the galvanometer boom when the mark is made on the paper. The thermocouple circuits may be those of either Figs. 5, 6 or 7, but with the galvanometer G_2 indicating temperatures suppressed.

It is evident that by recording the two curves $\theta - \theta'$ vs t and θ vs t on the same sheet there is some sacrifice in the ability to detect small and rapid transformations, since the spacing is doubled. On the other hand, it is of great advantage to have the curves together and obtained independently of inequalities in clock-rates, which are a serious source of error in locating transformation points exactly when two separate instruments are used.

When it is desired merely to detect the existence of a transformation without measuring its temperature exactly, the sensitive form of recording millivoltmeter may be connected directly to the differential thermocouple without other accessories.¹⁷

IV. θ vs $\theta - \theta'$.—It is sometimes of advantage to be able to record and discuss the data independently of the time, and so express $\theta - \theta'$, the difference in temperature between sample

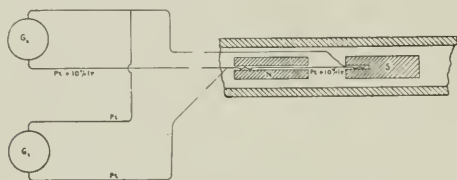


FIG. 6.—ROBERTS-AUSTEN DIFFERENTIAL METHOD.

temperature range studied, such as a piece of platinum, porcelain, or even in some cases nickel or nickel steel. It is also desirable that the sample and neutral have as near as may be the same heat capacities and emissivities. The sample to be studied and the neutral piece are placed near together and arranged symmetrically with respect to the temperature distribution within the furnace.

To Roberts-Austen¹⁵ again was due the credit of first devising a sensitive differential method using the neutral body. He also modified his photographic recorder (Fig. 1) so as to give, by means of a second galvanometer, the $\theta - \theta'$ vs t curve on the same plate with the θ vs t curve, from which a curve giving $\theta - \theta'$ in terms of θ could be constructed.

His arrangement of the direct reading and differential thermocouple and galvanometer circuits is shown in Fig. 6 in which S is the sample or test piece and N the neutral body possessing no transformations; the galvanometer G_2 measures the temperature θ of the sample, and G_1 measures the difference in tempera-

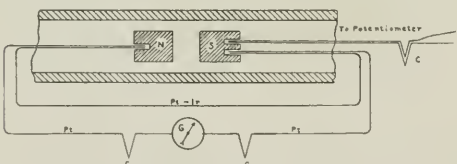


FIG. 7.—MODIFICATION OF DIFFERENTIAL METHOD.

ture $\theta - \theta_1$ between the sample and the neutral. Curves for steels and alloys were usually taken with the samples in vacuo.

It is evident that Roberts-Austen's final photographic apparatus, although very sensitive, was also complicated and very delicate of adjustment, and in practice it took great skill in its

¹⁵ Fifth Report of the Alloys Research Committee, *Proc. Inst. Mech. Engrs.*, p. 35; 1899. *Metallographist*, 2, p. 186; 1899.
¹⁶ See for example: Carpenter and Neeling, *Collected Researches, Natl. Phys. Lab.*, 2, 1907.

¹⁷ Hoffman und Rothe, *Zs. Instrumentenk.*, 25, p. 273; 1905.

and neutral, directly in terms of θ , the temperature of the sample. This may evidently be accomplished by replotting the results obtained from the curves of the previous differential methods which involve the time. It was reserved, however, to Saladin, Engineer of the Creusot Works, to invent, in 1903, a method¹⁸ that would record photographically the θ vs $\theta - \theta'$

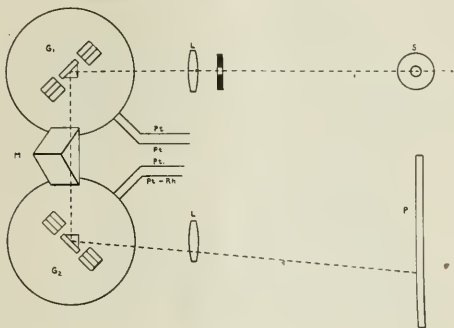


FIG. 8.—ARRANGEMENT OF TEST.

curve directly, thus obviating any replotting. His method possesses also the advantage of having the photographic plate fixed in place. The forms of curve obtained in this way are illustrated in Plate I, Fig. IV.

The arrangement of the apparatus in its simplest form, due to Le Chatelier,¹⁹ is shown in Fig. 8. Light from the source S strikes the mirror of the sensitive galvanometer G_1 , whose deflection measure the differences in temperature ($\theta - \theta'$) between the sample under study and the neutral body. The horizontal deflections of the beam of light are now turned into a vertical plane by passing through the totally reflecting prism M placed at an angle of 45° . A second galvanometer G_2 , whose deflections are a measure of the temperature of the sample and whose mirror in its zero position is at right angles to that of G_1 , reflects the beam horizontally upon the plate at P.

The spot of light has thus impressed upon it two motions at right angles to each other, giving, therefore, on the plate a curve whose abscissæ are approximately proportional to the temperature θ of the sample and whose ordinates are proportional to $\theta - \theta'$. The sensitiveness of the method depends upon that of the galvanometer G_1 , which may readily be made to give five or six millimeters for each degree centigrade.

The arrangement of the thermocouple circuits is the same as in Figs. 6 or 7. If so desired, the time may also be recorded by means of a toothed wheel driven by a clock and placed in the path of the beam of light. Compact forms of this apparatus, which are used considerably in metallurgical laboratories, are made by Pellin, Paris, and by Siemens & Halske, Berlin.

When steels and metallic alloys in the solid state are being investigated, advantage may be taken of the thermoelectric behavior of the sample itself to record the critical regions with Saladin's apparatus. Thus Boudouard²⁰ measures $\theta - \theta'$ by means of platinum wires set into crevices at each end of the sample, taking advantage of the fact that the transformation will usually be progressive along the sample.

This modification eliminates the neutral piece and one platinum or alloy wire, but, as Le Chatelier has shown,²¹ is less accurate than the usual form of Saladin's apparatus; and its indications may even be indeterminate or ambiguous, as the reaction may start midway between the embedded wires or at either end.

¹⁸ Saladin: New autographic Method to Ascertain the Critical Points of Steel and Steel Alloys, *Iron and Steel Metallurgy and Metallography*, 7, p. 237; 1904. First presented at Reunion des Membres Français et Belges de l'Association Internationale des Methodes d'Essais 28 Feb., 1903.

¹⁹ H. Le Chatelier, *Rev. de Metallurgie*, 1, p. 134; 1904.

²¹ *Rev. de Metallurgie*, 1, p. 134; 1904.

Saladin's method, it should be noted, is a perfectly general one for recording the relations between any two phenomena which may be measured in terms of e.m.f. or as the deflections of two galvanometers. This method cannot readily be made autographic, as this would require the simultaneous action of two galvanometer systems on a single pen. When used as a direct reading method it reduces to III.

IVa. θ vs $\theta - \theta'$ $\Delta\theta$.—For even moderately rapid cooling the differential method gives distorted curves which are often difficult of interpretation. This distortion is due largely to the different heat capacities and emissivities of the sample and neutral piece, thus causing differences in their rates of cooling in the furnace. Rosenhain has suggested (l. c.) that these irregularities may be eliminated by taking what he calls the "derived differential curve," or expressing the temperature θ of the sample in terms of the difference in temperature $\theta - \theta'$ between the sample and neutral for equal temperature decrements $\Delta\theta$ in the sample.

The experimental method is the same as in IV, but in addition it is necessary to replot the data obtained from the θ vs $\theta - \theta'$ measurements so as to give the value of $\theta - \theta'$ per degree change in temperature of the sample in terms of its temperature; but this appears to be worth while when the cooling curves of the sample and of the neutral differ considerably.

(To be concluded.)

Grinding.

By OSKAR NAGEL, Ph.D.

The grinding of raw materials and finished products is of such industrial importance that the selection of the proper apparatus has to be made with the greatest care. The suitability of a mill depends upon the nature of the material to be handled, the capacity required and the fineness desired. The selection is greatly facilitated by the experimental laboratories which are maintained in the shops of many of the large manufacturers of mills and are at the disposal of prospective customers.

Generally speaking, grinding appliances can be divided into two types—machines for crushing and coarse grinding, and machines for the production of a fine powder.

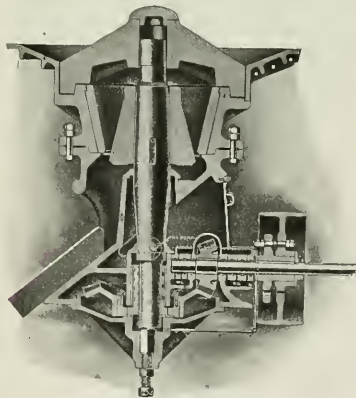


FIG. 1.—GYRATORY CRUSHER.

Gyratory Crushers—The gyratory type, shown in Fig. 1, which is used in almost all cement mills, as well as in other industries, has a vertical spindle on the upper end of which is mounted a chilled-iron crushing head, which moves inside a hopper-shaped top into which rock is fed. The bottom of the spindle passes loosely through an eccentric, driven from a horizontal shaft by bevel gears. The spindle, therefore, has a

²⁰ O. Boudouard, *Rev. de Metallurgie*, 1, p. 80; 1904.

gyratory motion, and may or may not rotate on its own axis.

As the head, running eccentrically, approaches and recedes from the side of the hopper, the stone is gradually crushed and falls down between the crushing surfaces. The stone must be broken by hand to a convenient size to feed into the hopper. A crusher having a hopper about 40 inches in diameter and a crushing head about 20 inches will have a stroke of approximately $\frac{5}{8}$ inch.

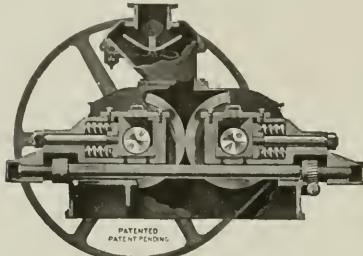


FIG. 2.—CRUSHING ROLL.

The horse-power necessary to drive averages 1 to 2 times the tons of rock crushed by hour, figuring on rock of moderate hardness. A crusher of this type is suitable for individual belt drive. Sometimes two or more crushers are belted to one motor, though this is not the best practice, as all crushers must be stopped when the motor is shut down. Gearing is not suitable for these machines, as the driving gear would be subject to severe strain should the crusher become clogged with rock.

Crushing Rolls.—These machines are built with plain or corrugated rolls. Their construction is easily understood from Fig. 2.

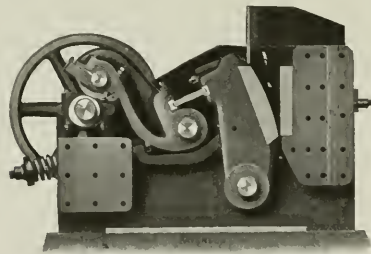


FIG. 3.—JAW CRUSHER.

Jaw Crushers.—In this type the pressing force of a moving jaw is utilized for crushing the material. This is a simple and effective crusher of moderate cost, capable of crushing the hardest material. It is illustrated in Fig. 3.

The Open-Door Rotary Fine Crusher, shown in Fig. 4, is built by the Sturtevant Mill Co., of Boston, Mass., in capacities from 1000 lbs. to 35 tons per hour. In this mill, which is widely used for soft and moderately hard materials, every part of the interior is easily accessible for replacement and inspection.

The Stamp Mill, shown in Fig. 5, is probably the oldest crushing machine and the most convenient for certain materials, as it does not get out of order and requires very little attendance.

Ball Mills.—In cement works these mills take the output of the crushers and reduce it to a coarse grit. A drum, having a diameter of about double its length, is filled with steel balls and revolves around a horizontal axis at a speed of from 21 to 27 revolutions per minute. The lining of the drum is made up of overlapping steel plates which form steps. As the drum revolves, the balls drop over the steps, pounding the material to pieces.

The tube mill consists of a wrought iron tube mounted on a shaft by the attachment of heads so formed as to make turn

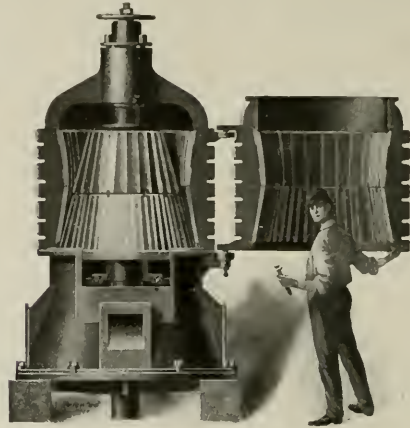


FIG. 4.—OPEN-DOOR ROTARY.

nions, which rest in bearings at both ends or supported by tires securely attached to the shell. A large gear attached to the tube and a pinion attached to the pulley shaft make the actuating device. The tube is lined with siliceous stone, and is about one-half filled with flint pebbles. The large grinding surface thus provided permits of a very slow rotation, 22 to 27 revolutions per minute, according to the size of the machines. The trunnion at the feed end is hollow, and a screw conveyor carries in the material. By simply regulating the feed, any degree of

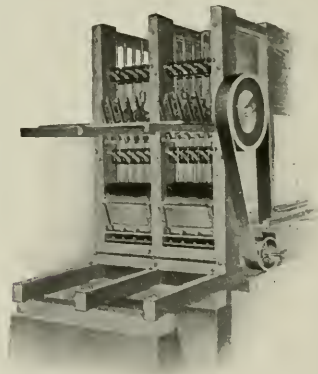


FIG. 5.—STAMP MILL.

fineness, even to impalpable powder, may be obtained. Fig. 6 shows the tube mill built by F. L. Smidth & Company, New York. Fig. 7 shows the spiral feed and discharge which are the characteristic features of the tube mill of the Abbe Engineering Co. A detailed description of the popular tube mill of this company will be found in Vol. III, p. 6, of this journal.

Kominuters.—The kominuter is one of the latest developments on the line of low speed coarse grinders. It combines to some extent the best features of the ball mill and the tube mill, resulting in increased capacity per horse-power, and a decreased cost of repairs over ball mills; compared to a ball

mill having the same volume of grinding room, and requiring approximately the same horse-power, the kominuter can carry more balls than the ball mill; it has also more screen surface and has a higher efficiency per square foot than the ball mill, the wire cloth being the same in both cases. The kominuter gives a higher output per horse-power than the ball mill, is

tained; the roll revolves against the die in the direction of the pulley, and this contact causes the roll and shaft to revolve around their own axes in opposite directions. These mills are best adapted to belt-drive, and may be driven by a vertical motor, or a horizontal motor with a quarter-turn belt. The Griffin mill is manufactured in two sizes—30 inch and 36 inch—

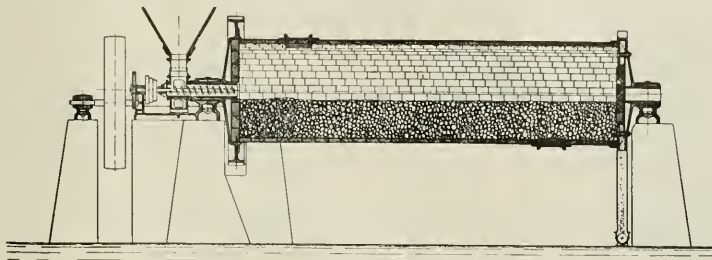


FIG. 6.—TUBE MILL.

self-contained, is provided with automatic feed, and automatically returns to the mill the tailings from the screens. Fig. 8 shows a kominuter built by F. L. Smidth & Co., New York.

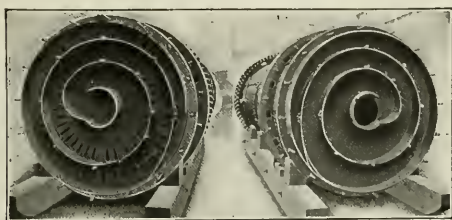


FIG. 7.—SPIRAL FEED AND DISCHARGE.

Griffin Mills.—These mills are used for the fine grinding of cement and other materials. The mill shown in Fig. 9 is driven from a pulley at the top, revolving on a vertical axis. The power is transmitted to a vertical shaft, which is hung from a universal joint inside the pulley and is free to move in any

designated according to the diameter of the ring against which the crushing roll revolves.

A new mill has been brought out by the manufacturers of the Griffin mill (The Bradley Pulverizer Co.) called a Three Roll Griffin Mill. This is similar in its action to the standard mill, but, as the name implies, has three crushing rolls instead of one.

Fuller Lehigh Mills.—These are called Fuller mills. They are used on the same material as the Griffin mill described above, and the grinding is done by four chilled-iron balls about 9 inches in diameter that are propelled by four equidistant horizontal arms or pushers radiating from a vertical central shaft. The orbit is a circular die against which the balls exert great pressure, since they weigh about 112 pounds each and revolve at about 210 revolutions per minute. The main shaft is driven from a pulley mounted at the bottom below the grinding level. This mill, which is shown in Fig. 10, is built by the Lehigh Car Wheel & Axle Works, Catasauqua, Pa.

The Kent Pulverizer, which is also widely used for coarse and fine grinding, is illustrated in Fig. 11 in a sectional view. The ring revolves and the three rolls press against its inner face. These are the only four wearing parts. The rolls are convex and are provided with guides, while the ring is concave.

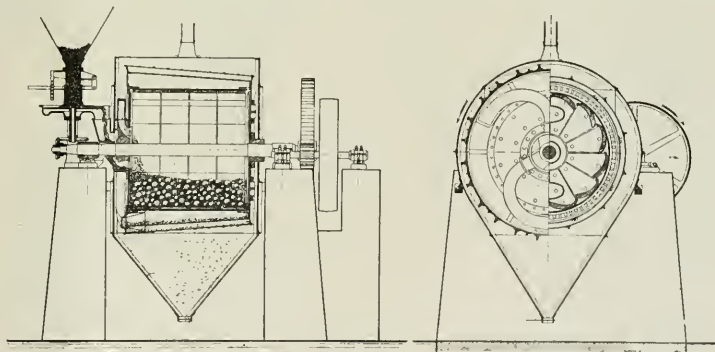


FIG. 8.—KOMINUTER.

direction at the bottom. A crushing roll is rigidly connected to the bottom of the shaft. When the pulley revolves the crushing roll is thrown off center and revolves against a fixed ring or die with a centrifugal force of about six thousand pounds pressure. The grinding is done between these two surfaces.

Two distinct actions on the material to be ground are ob-

The springs supporting the rolls yield, and the rolls support the ring, so that the four crushing parts are free to move in order to pass iron or uncrushable material. The rolls are cushioned so as to overcome shock and vibration and prevent crystallization or breakage.

The rock falls from the inlet to the inner face of the ring. Centrifugal force holds it there in a layer an inch deep. It

revolves with the ring, and passes under the rolls. The rolls are pressed by the springs outwardly against the rock on the ring with a pressure adjustable to 20,000 lbs. by the screws against the springs. The rolls pass over the rock, crushing it against the ring. The crushed rock falls off each side of the

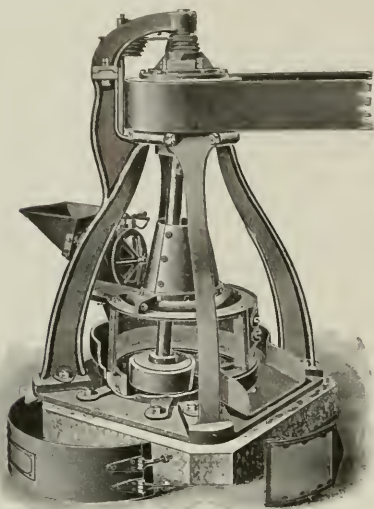


FIG. 9.—GRIFFIN MILL.

ring into the casing and thence to the discharge. The body of the rock between the rolls and the ring make 90 per cent of the rock abrade on itself in crushing, thus reducing the wear on the moving parts. This mill is built by the Kent Mill Co., New York.

Impact Pulverizer.—A mill which is widely used on account of its convenient accessibility to its inner parts is built by the

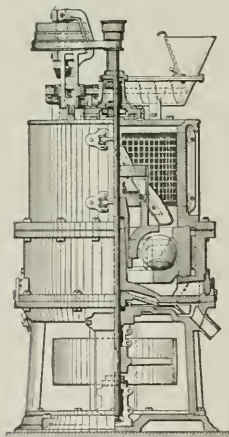


FIG. 10.—FULLER MILL.

Raymond Brothers Impact Pulverizer Company, of Chicago. For grinding finer than to 100 mesh, air separators are attached to this mill, as illustrated in Fig. 12.

For pulverizing coal and for transporting the coal dust mixed with the amount of air necessary for combustion to a kiln or

furnace the so-called **Aero Pulverizer**, shown in Fig. 13, is successfully used. This machine consists of several chambers of successively increasing diameter with interior communication in which revolve paddles on arms with correspondingly increased radii. Three of these chambers are in fact separate pulverizers on a single axis, each succeeding pulverizer having longer arms and therefore greater speed at the periphery, and greater power for fine pulverization. The fourth chamber con-

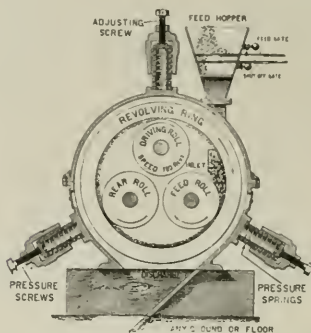


FIG. 11.—KENT MILL.

tains a fan whose function it is to draw the more finely pulverized material successively from one chamber to the other and finally to deliver it through a pipe connection to the furnace with the impetus of a forced draft. The three pulverizers and fan are enclosed in one steel cylinder.

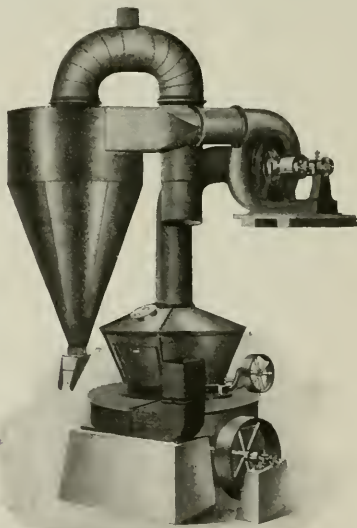


FIG. 12.—IMPACT PULVERIZER.

A regulating feed device accurately controls, and by moving a lever, varies the quantity of coal admitted to and delivered by the machine. The inlets in the feed device admit the air required for pulverizing purposes. An auxiliary inlet between the third work chamber and the fan is controlled by a damper and admits such additional air as is required to bring the total

air supply up to the theoretical requirement. The auxiliary air is intimately mixed with the pulverized coal in the fan

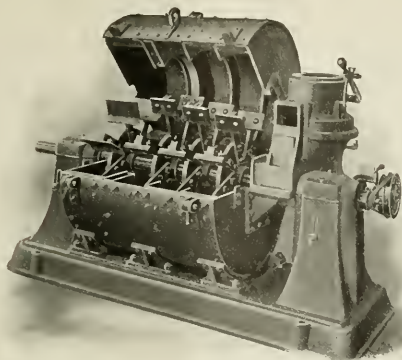


FIG. 13.—AERO PULVERIZER.

chamber. These machines are built by the Aero Pulverizer Co., of New York.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our London Correspondent.)

The Institution of Mining and Metallurgy.

Accumulation and Absorption of Gold Amalgam by Copper Plate.

Owing to pressure of other matter notice of two papers on this subject discussed at the meeting on May 21 has been held over. The first of these, by EDWARD HALSE, gives detailed particulars of the gold retained by three sets of silvered plates (apron) in a mill at Sucre, Colombia, which had accumulated during a period of rather more than six years. The one milled was pyritic and consisted mainly of quartz with some (rarely visible) free gold.

The four plates of the first set were taken up at the end of 26 months and "burnt." During that period 4462 tons of high-grade ore passed over them, with an average yield of 19.62 dwt. of fine gold, followed by 3453½ tons of tailings, with an average yield of 2.58 dwt. of fine gold per ton (2000 lb.).

The gold scale from the four plates weighed 937 oz., and the average rate of accumulation was 1.269 dwt. of fine gold per ton milled.

The four plates of the second set were taken up at the end of a similar period, during which 1172 tons of tailings, with an average yield of 1.95 dwt. of fine gold, followed by 2175 tons of low-grade ore, with an average yield of 6.80 dwt. of fine gold per ton passed over them.

The gold scale amounted to 508 oz., which gives an average rate of accumulation of 1.823 dwt. of fine gold per ton milled.

The four plates of the third set were allowed to run for 24 months only. The ore crushed during that period amounted to 2860 tons of medium grade, yielding 11.13 dwt. of fine gold per ton.

The gold scale from these plates weighed 553.68 oz., giving an average rate of accumulation of 2.071 dwt. of fine gold per ton.

The average accumulation of hard amalgam per ton works out at 1.721 dwt. of fine gold. At the Drum Lummon mine, about 12 years ago, Mr. R. T. Bayliss obtained an average of 0.499 dwt. fine gold per ton milled. The grade of ore at Sucre was about double that at Drum Lummon; and, no doubt, other things being equal, the richer the ore the greater the accumulation. From the results at Sucre it would appear that the richest

ore gave the lowest rate of accumulation, but this is accounted for by abnormal conditions, interruption and milling of tailings. The author states that it is well known that very low grade ore will gradually remove hard amalgam that has accumulated on plates from rich ores which have previously passed over them, and considers the low rate of accumulation with the first set is thus explained. In the case of the second set of plates there was practically no "scouring" for the milling of the low-grade tailings was followed and not preceded by the milling of ore (low grade). During the third period the conditions were quite normal. Medium-grade ore had by that time become available, and no tailings were passed through the mill. So that, at Sucre, working under normal conditions, the average rate of accumulation of hard amalgam was as much as 2 dwt. of fine gold per ton, or four times higher than was the case at Drum Lummon. The gold actually absorbed by the plates, and only recoverable by melting them down, was 0.288 grain per ton milled at Drum Lummon, and certainly less than 1 grain per ton at Sucre. The average rate probably does not exceed a fraction of a grain per ton.

The other paper was by W. E. THOMAS, who quoted the statement made to him by the manager of a large gold mine on the Rand that "every new plate in a gold mill will absorb and lock up about 70 oz. of gold;" and remarked that one frequently hears the statement, when a new mill has started with a disappointing return, that it was due to the absorption of gold by the new plates. To what extent is this justified? If the two statements were combined one might jump to the conclusion that the first crushing return of a new mill is reduced by about 70 oz. for each copper plate it contains. Such a conclusion, however, would require very considerable modification.

Consideration of results obtained at the Drum Lummon and Hidden Treasure mines by R. T. Bayliss and A. L. Collins, respectively, appear to justify the following general conclusions:

1. The amount of gold actually absorbed by a copper plate, 4 ft. 6 in. x 8 ft. to 12 ft., is not likely in the long run to amount to more than 8 to 10 oz., and generally not more than half of this, if as much, will affect the first month's crushing returns.

2. The amount of gold retained on a plate in the form of amalgam scale is a variable factor, depending largely on the capacity of the millman and the discretion of the manager.

Though apparently there are cases where the amalgam scale is allowed to accumulate to a large extent, that is not the general practice, and in any case the accumulation during the first month, when the plates are new, will represent only a proportion of the final accumulation.

Thus it would appear that generally the first month's run of a gold mill with new plates is not affected by such a serious loss in locked-up gold as is sometimes attributed to it, or inferred.

Finally, in connection with this subject, the author enquired why Muntz metal plates are not more generally used. They should be cheaper than copper plates, they absorb practically no gold, the amalgam scale does not adhere to them so obstinately and they are hence more easily cleaned up.

The Mining Exhibition.

As is natural in a country whose chief mineral wealth is carboniferous, the chief features of the Mining Exhibition held in London this month have had relation to the use of electricity in coal mines. Haulage gear, conveyors and coal cutters, electrical safety lamps, motor-driven centrifugal pumps, were exhibited in both old and new patterns. An Ingersoll Rand electric air drill calls for mention as new to British practice. This apparatus consists practically of an ordinary compressed air percussion drill actuated by a small electrically-driven compressor on a truck. The main advantage claimed for this system of drilling is that it combines the economy of electrical as against pneumatic transmission, with the simplicity and cushioned blow of the air drill, and only requires about one fifth of the power of the latter. The cylinder is divided into two parts, each with its own piston. Each piston is driven by the air from

one air cylinder of a small electrically-driven air pump without valves by means of a separate tube. The two drill pistons run synchronously with the air pump pistons, and the quantities of air in each half of the drill cylinder act as air cushions at the same time. The air is always the same, and is saturated with oil so as to act as a lubricant. This drill is exceedingly simple and requires very little repairing. The output or speed of the strokes can easily be varied by means of the motor driving the air pump. It requires, of course, more room than the purely electric drills on account of the air pump, although this is very compactly arranged, but is quite suitable for large stopes and easy tunneling work. The outfit shown is driven by a 2-hp, three-phase motor, and is intended for holes 6 to 8 ft. deep.

The Grondal Kjellin Company, Limited, exhibited a model of a Kjellin induction steel furnace. The model exhibited, however, has not the renewable hearth with which the latest types are fitted. Samples of steel produced in the Kjellin and Rochling-Rodenhauser electric induction furnaces are also exhibited. Samples of electrically-melted steels, including diamond-tungsten and chrome steels are shown by Messrs. Sybry, Searls & Company, Limited, of Cannon Steel Works, Sheffield, who produce all these classes of steel from the raw Swedish iron by means of the Kjellin furnace.

Scientific and Technical Symbols.

A subcommittee of the International Electrical Commission has recently been advocating an attempt to establish a system of scientific symbols which shall be the same for all languages. While chemistry has the great advantage of being equally comprehensible throughout the learned world, electricity requires of the student further education if he is to understand the many valuable contributions to knowledge on the subject continuously emanating from, for example, France and Germany. The simplification of international patent specification would also be invaluable, as, at the present time, it requires not only an acquaintance with the colloquial portions of a foreign language, but also an intimate experience of the technical equivalents to check the foreign version of a patent. In an article written at the request of the subcommittee above mentioned, Mr. Miles Walker, while recognizing the desirability of a recognized code of symbols, admits at once the two leading difficulties in the way of establishing it. In the first place there is the difficulty of training the mind in the case of persons thoroughly and daily accustomed to recognize a certain symbol as having a certain meaning to ascribe to it a quite different meaning; and, in the second, the fact that there are not enough letters in the two or three alphabets in common use to give a distinct symbol to each quantity. The use of combinations the writer very reasonably objects to as hindering the classification of the quantities of the same kind by the simple addition of subsidiary figures or lettering now in common use. He suggests the creation of new symbols to meet the latter difficulty. As this has already been done, for a somewhat similar purpose, in the various systems of shorthand with entirely satisfactory results, this expedient seems quite feasible. The publication and deposit at some suitable establishment (such as the library of one of the scientific institutions) of a code of symbols would ensure their permanency of signification in case of legal or other dispute as to their meaning. The spread of typewriting may be taken as either for or against this proposal. On the one hand, the elimination of difficulties caused by illegible writing is secured, while, on the other, the size of the machine must be much increased to comprehend all the symbols likely to be in use.

Reinforced Concrete.

The question of the durability of the steel structure in concrete has often been raised without very much practical data as a result. At the National Physical Laboratory (London) some tests were recently carried out at the request of Sir John Brunner to determine the effect produced on mild steel by being embedded in concrete. The official report is as follows:

"A strong wooden box was made and divided into five partitions, each partition being 12 in. long, 7½ in. wide and 7½ in. deep. Specimens of mild steel of the following dimensions were prepared: (1) 1 in. in diameter, 8 in. long, turned all over; (2) 8 in. lengths cut from a 1½ in. by 1½ in. bar with the scale left on. The partitions were half filled with good Portland cement concrete, and a specimen of each kind laid on the top, and the partitions were then filled up. This was done on December 21, 1906. The blocks were covered with water several times a week for a year, and for three months afterwards were left in the open subject to the weather. On April 20th one of the blocks was removed from the box and broken up, and the specimens removed. On examining the specimens carefully no trace of any action by the cement could be detected. The turned specimen was practically as bright as when it was put in, and the scale on the rough specimen was undisturbed. To test the possibility of any slight action the surface of the turned specimen was polished and etched and examined under the microscope side by side with a specimen of the same material cut from the center of the bar. No difference in the micro-structure of the two specimens could be detected, and the conclusion is that in sixteen months no action has taken place between the metal and the concrete. It is proposed to immerse one of the remaining blocks in the comparatively warm water of the cooling pond for six months, and then to examine the specimens."

While these experiments are of the highest value, it will be of still greater interest if it can be ascertained what effect samples of concrete taken from actual working mixtures in use in various cities would have under similar circumstances.

Market Report for July.

Tin has fluctuated considerably during the last month. Starting on the 1st at £124 per ton, unusually low, it commenced to rise gradually, and afterwards sharply, till by the 9th it had reached £132. It then fell to £130, rising, however, by the 17th to £135. Another drop followed, after which the price rose to £138 on the 30th.

Copper has been fairly steady throughout the month at or about £58, rising during the last week to £60. Prices on the 30th, £59.5.0.

Eng. Lead has been firm at about £135.0 during the month. *Hematite*: Steady throughout the month at 58/-.

Cleveland Warrants: Tendency lower. 51 - up to the 18th, then falling gradually to 50/-. Price on the 30th £25.10/6.

Scotch Pig: Steady in the neighborhood of 56/-, with inclination to lower after the 15th.

Chemicals:

Ammonia Sulphate F.O.B. Liverpool, per ton.....	£11. 17. 6
Copper Sulphate, per ton.....	20. 0. 0
Caustic Soda, 77 per cent, white, per ton.....	11. 2. 6
Bleaching Powder, 35%, per ton.....	4. 8. 0
Antimony, Regulus, per ton.....	£33 to 34. 0. 0
Shellac, Standard T. W. Orange spots, per cwt.....	6 10. 0
Carbolic Acid, liquid 97 to 99%, per gal.....	11
Cresosote, good ordinary liquid, per gal.....	2 1/16
Naphtha Solvent, 60% at 100° C., l. o. b., gallon.....	10
Rubber, Para fine, per lb.....	1. 8 3/4

American Electrochemical Society. At the last meetings of the board of directors the following gentlemen were elected members of the society: E. G. Acheson, Jr., Niagara Falls, N. Y.; William H. Arison, Niagara Falls, N. Y.; William C. Bray, Boston, Mass.; W. R. Clymer, Cleveland, Ohio; Orrin E. Dunlap, Niagara Falls, N. Y.; C. M. Fitzgerald, New York City; Charles E. Foster, Rochester, N. Y.; A. J. Guerber, Allentown, Pa.; Henry D. Hibbard, Plainfield, N. J.; George M. Kebbe, Brooklyn, N. Y.; C. Le Bontillier, High Bridge, N. J.; A. S. McAllister, New York City; E. C. Sprague, Niagara Falls, N. Y.; John H. Thickets, Appleton, Wis.; George N. Tidd, Scranton, Pa.; Edmond A. White, Port Kemble, New South Wales, Australia. The fall meeting will be held on Oct. 29, 30 and 31 in New York City. The spring meeting, next year, will be held in Niagara Falls. The thirteenth volume of the *Transactions* has just been issued. It is a fine volume of 48 pages and contains the complete record of the last meeting held in Albany.

SYNOPSIS OF PERIODICAL LITERATURE.

Theoretical and Experimental.

Formation of Metallic Dust from Cathodes in Dilute Gases.—F. Kohlschütter and Th. Goldschmidt have studied experimentally the formation of metallic dust from cathodes in glow discharges and give an account of their research in *Zeit. f. Elektrochemie*, April 24. It has already been found before that the quantity of dust produced depends not only on the nature of the metal, but also on that of the gas in the discharge tube. This has led to a chemical theory of the phenomenon, according to which the cathodes are attacked in dilute gases, whereby endothermic compounds of gas and metal are formed, which then decompose again, giving off metallic dust. In the present investigation the phenomenon was studied quantitatively, with special reference to the above theory. Cathodes of Al, Fe, Cu, Ag, Pt and Au were used in H_2 , He, N_2 and Ar. While the cathodic formation of dust has some similarities with the dust formation from electrically heated incandescent wires, yet it is not certain that both phenomena do belong together. At higher pressures (1 mm) the dust formation is not caused by the escape of occluded gas from the cathodes. Small quantities of oxygen in another gas do not increase the cathodic dust formation in such an abnormal way as is the case with an incandescent wire. The metals can be arranged in a series according to their liability of dust formation and their order in this series is the same in all gases. The loss of weight of the cathodes is proportional to the equivalent weight of the metal, other things being equal. The gases may also be arranged in a series according to their ability of attacking the cathodes, and their order in this series is the same for all metals. It is the same order as that of the atomic weights. *Zeit. f. Elektrochemie*, July 3, contains a preliminary account of an investigation of the same phenomenon by F. Fischer and O. Haeßel, who always used two discharge tubes in series. If the pressure of the gas is the same and the same cathodes are used in both tubes, the same quantity of dust is formed in both. If the gas pressure is not the same, the formation of dust is approximately inversely proportional to the gas pressure. The result of Kohlschütter and Goldschmidt that the order of the gases is the same as that of the atomic weights is contradicted. V. Kohlschütter replies to these criticisms in *Zeit. f. Elektrochemie*, July 31, explaining the scope of his extended investigations on this subject.

Electroanalysis.—The polemics between F. Foerster and A. Classen concerning high-speed methods in electroanalysis is continued in *Zeit. f. Elektrochemie*, April 17 and 24. In the same journal, May 8, O. Scheen discusses the electroanalytic determination of antimony, while in the issue of May 29, E. Cohen criticizes some points in this paper. The electrolytic determination of nickel in nitrate solution and its separation from copper is discussed by A. Thiel in *Zeit. f. Elektrochemie*, April 17. He finds that the electroanalysis of nickel in nitrate solutions is always successful, if proper precautions are taken (for instance, use of straight passive iron wires as anodes).

Silver Peroxide.—From experiments with a diaphragm cell, containing silver nitrate in both compartments and having an anode and a cathode of platinum, with an anodic current density of 0.07 ampere per square centimeter, G. Baborovsky and B. Kuzma (*Zeit. f. Elektrochemie*, April 10) conclude that the primary formation of silver pernitrate, $AgNO_3$, at the anode, is very probable.

Electrolysis of Fused Calcium Chloride.—According to K. Arndt and K. Willner (*Zeit. f. Elektrochemie*, April 17) the decomposition voltage of fused calcium chloride at $800^\circ C.$ is about 3.24 volts.

Chemical Thermodynamics.

Nernst's Theorem.—In recent years W. Nernst, with many of his students, has paid special attention to a new theorem of

thermodynamics. The well-known Gibbs-Helmholtz equation states that $\Delta - Q = T d\Delta/dT$, where Δ the change in free energy (the maximum amount of work obtainable from the reaction at the constant temperature T , if carried out in a reversible way), Q the "latent heat of the reaction" (the change in total energy, if the volume remains constant), and T the absolute temperature. At the absolute zero point of temperature Δ evidently equals Q . Nernst's new theorem makes the further assumption that $\lim d\Delta/dT = \lim dQ/dT = 0$ for $T=0$. This hypothesis leads to very interesting consequences. (The best summary of the whole theorem, now available to American readers, is contained in Nernst's lectures, held at Yale in 1906, on Experimental and Theoretical Applications of Thermodynamics to Chemistry, recently published in book form by C. Scribner's Sons.) Two recent investigations refer to this theorem. The equilibrium $SO_2 + Cl_2 = SO_2Cl_2$ is studied by M. Trautz, E. Baisch and A. von Dechend in *Zeit. f. Elektrochemie*, May 15. The application of Nernst's theorem to the thermodynamical calculation of electromotive forces is discussed by F. Halla in *Zeit. f. Elektrochemie*, July 24. The experimental results obtained with the two cells Ag, Cl, Pb, Cl_2 (saturated), Pb and Ag, Ag, Cl, Hg_2, Cl_2 (saturated), Hg are found to be in good agreement with Nernst's theory.

Ammonia Equilibrium.—The old controversy between W. Nernst and F. Jost on one side and F. Haber on the other side concerning the exact figures for the equilibrium of the reaction $N_2 + 3H_2 = 2NH_3$ is reopened by F. Haber and R. LeRossignol in *Zeit. f. Elektrochemie*, April 10, where they give an account of determinations of the equilibrium at various temperatures up to $1,000^\circ C.$ and at a pressure of 30 atmospheres. The results confirm former results of Haber and Van Oordt for atmospheric pressure and their figures disagree at higher temperature to some extent from the experimental results of F. Jost. The latter, in his reply in *Zeit. f. Elektrochemie*, July 10, thinks, however, that the disagreement is not so very bad.

Industrial Electrochemistry.

Silicon as Reducing Agent.—B. Neumann discusses again (*Zeit. f. Elektrochemie*, April 3) the use of silicon as reducing agent for refractory oxides. In an electric furnace with two vertical electrodes (Heroult type) he melts lime or alumina or a mixture of both, and to this highly heated bath (melting point $1,100^\circ$ to $1,450^\circ C.$) he adds a mixture of the refractory oxide to be reduced (for instance, of chromium) and an equivalent amount of silicon or ferrosilicon. The reaction then starts at once, the silica which is formed is absorbed by the lime-alumina mixture, while the reduced metallic particles (of chromium, etc.) sink to the bottom and form a regulus. The author made experiments on the production of ferrochrome, ferrotungsten, titanium and molybdenum. It is possible to produce in this way low-carbon metals or alloys, but they always contain some silicon (some 2 per cent), but this the author considers to be no disadvantage for the steel industry.

Discharges Through Gases.

Fixation of Atmospheric Nitrogen.—The question whether the combination of nitrogen and oxygen as a result of an arc discharge through air is purely a thermal effect (so that the electric discharge simply serves for heating the air) or whether there is a specific electric effect involved, is discussed by G. Brion in *Zeit. f. Elektrochemie*, May 1. Simple heating of air causes, of course, combination of oxygen and nitrogen, but the question is whether in an electric discharge there is not an additional specific electric effect. If the ionic theory is applied to gases heated by electric discharges we have energy centers of maximum kinetic energy, surrounded by zones of gradually diminishing energy. It is difficult to apply the conception of purely thermic formation of NO from N and O to such conditions of the electric discharge. In the first place, if we take the resulting total heating of the gas mass as the basis of the thermodynamical calculation of the NO formation, we

get much smaller values than are found in practice. On the other hand, all thermic theories are based on the applicability of the law of mass action, and this is hardly applicable for electric discharges, especially at low current densities. For this reason the thermal theory leads to wrong conclusions for slow discharges, while the conclusions are in better agreement with the results obtained at high temperatures ($4,000^{\circ}\text{C.}$) with large quantities of energy.

Ammonia Formation.—Similar problems are discussed by M. LeBlanc and J. H. Davies in *Zeit. f. Elektrochemie*, July 3, with special reference to the equilibrium $3\text{H}_2 + \text{N}_2 = 2\text{NH}_3$. The formation of ammonia under the influence of the silent discharge was studied and it is found that the law of mass action no longer holds good. In the first moments of the electric operation the output of ammonia is a maximum, but is not high enough to render commercial application of the process promising. "If in an electric field (zone of electric action) the law of mass action is found to hold good, we can conclude that the equilibrium corresponds to the thermodynamical principles. If not, we can assume that we have to do with a more or less specific electric effect."

Batteries.

Edison Accumulator.—In *Zeit. f. Elektrochemie*, May 22, F. Foerster gives a further account of his very extended researches on the Edison iron-nickel cell. In the present paper he deals especially with the behavior of the electrolyte during charge and discharge and shows that it does not remain unchanged, as was originally supposed. The reaction at the nickel electrode appears to be $\text{Ni}_2\text{O}_3 + 1.2\text{H}_2\text{O} + 1.8\text{H}_2\text{O} = 2\text{Ni}(\text{OH})_2 + 2\text{OH}^+ + 2\text{F}^-$, where F is a positive charge of 96,540 contents. (A somewhat different reaction is assumed by Zedner, who writes $4\text{H}_2\text{O}$ instead of $1.8\text{H}_2\text{O}$.) The reaction at the iron electrode appears to be $\text{Fe} + 2\text{OH}^+ = \text{Fe}(\text{OH})_2 - 2\text{F}^-$. Hence the total reaction of charge and discharge of the Edison cell is $\text{Fe} + \text{Ni}_2\text{O}_3 + 1.2\text{H}_2\text{O} + 1.8\text{H}_2\text{O} = \text{Fe}(\text{OH})_2 + 2\text{Ni}(\text{OH})_2$. During discharge the electrolyte becomes more concentrated, during charge it becomes more dilute. Foerster discusses in detail the changes of specific gravity of the electrolyte during charge and discharge, and the influence of the concentration of the electrolyte on the e.m.f. In agreement with the theory, the e.m.f. decreases with increasing concentration.

Gold.

The Use of Borax in Assaying Gold Ores.—The results of some experiments carried out by Mr. J. E. Clennell on an ore similar in general character and appearance to Rand blanket ore, but practically free from pyrites, though carrying considerable quantities of iron in the form of black oxide, perhaps titaniferous, lead him to the following conclusions: 1. A large excess of borax gives a hard, stony slag, very difficult to separate clean from the lead button. In hammering out, the slag flies to pieces violently carrying with it a portion of the lead. Some part of the latter is sure to be lost unless extreme care be taken in collecting all the fragments. This, in the author's opinion, may explain some of the observed losses in the use of borax. 2. When no borax at all was used, the button usually separated quite clean from the slag. The latter was amber-colored and, while cooling, a scum of straw-colored crystals collected on the surface. The addition of borax rendered the slag distinctly more fusible. 3. The non-borax flux was considerably more deliquescent than the ordinary borax flux; it, however, caused no inconvenience, unless the fusions happened to be left in the molds for some hours after pouring. 4. By using a small quantity of borax in the charge, not exceeding 5 to 10 grams per assay ton of ore, it was found that a uniform fusible slag was produced without any noticeable amount of the above-mentioned scum. The buttons could be detached from the slag by a slight blow and none of the lead adhered to the slag. An average of 297 assays made without borax gave 18,169 dwt, while an average of 297 assays made on the same samples, with similar fluxes, but containing borax, gave 18,185

dwt, thus showing a slight advantage for the borax flux. The fluxes finally adopted were as follows:

Flux, parts by weight:	Mine and mill samples.	Cyanide and slimes.	Cyanide residues.
Bicarbonate of soda.....	2500	2400	3600
Fused borax glass.....	200	200	400
Litharge ..	2500	2400	3600
Charcoal ..	60	50	60

Weight of charge:

Ore for assay.....	1 A. T.	2 A. T.	2 A. T.
Flux (grams)	120	200	300
Cover of soda (grams).....	10	15	20

—*Journal of Chem., Met. & Mining Society of South Africa*, April, 1908.

Iron and Steel.

In the following notes we give brief abstracts of Iron and Steel Institute reports on research work carried out during 1907-08 by holders of Carnegie research scholarships.

Rusting of Iron.—Mr. J. Newton Friend reports on some experiments from which he concludes that the rusting of iron is primarily the result of acid attack. He found that steel and the purer forms of iron can be kept for an indefinite time in the presence of pure water and air without undergoing the slightest change. The introduction of the merest trace of acid, however, causes immediate corrosion. Cast iron, on the other hand, rapidly rusts in the presence of pure water and air "owing to the catalytic or electrolytic action of its numerous impurities." Neither water and air nor steam and air, at 100°C. , exert any action on the purer forms of iron, though a layer of oxide is immediately formed on introducing a trace of carbon dioxide. When iron has once begun to rust, further corrosion proceeds rapidly. This is due to the hygroscopic nature of rust, whereby its pores become saturated with moisture charged with carbonic acid. Hence, iron which has once begun to rust continues to do so in a moist atmosphere where rust-free iron would not be affected. The present author has succeeded in preserving a piece of partially rusted iron in contact with pure air and water without the slightest increase in the rusted area being apparent.

Sodium for Steel Refining.—Mr. A. Hiorth's report contains an incidental remark which will be interesting to electro-metallurgists. It appears that Mr. Ashcroft's electrolytic sodium works in Vadheim, Norway, are now in operation and producing metallic sodium. Hiorth made experiments with sodium as a refining agent for iron and steel, by introducing sodium in vapor form into the iron bath from beneath. The experiments were made on a very small scale, however, in crucibles containing 1 kg of charge. The effect of this treatment on the carbon, silicon, sulphur, phosphorus and manganese in the steel is very slight. But the sodium is effective in reducing the oxygen content in the steel quite essentially. Naturally, the heat, thereby developed, tends to render the steel more fusible. While sodium might be considered too expensive for such purposes, a valuable by-product is obtained in the form of sodium peroxide.

Quenching; Troostite, Austenite.—Dr. Carl Benedicks' report refers to four subjects: First, the cooling power of different liquids was studied. The cooling power of mercury was found to be considerably less than that of water, and to approach that of rape oil. The factor which plays the main rôle at the cooling in a liquid is the latent heat of vapor. The specific heat is only of secondary influence. The heat conductivity may be entirely neglected. "The essential condition for a quenching liquid to give effective cooling appears to be: (1) a high latent heat of vapor, and (2) so low a temperature that the vapor bubbles formed at the surface of the metal may be easily condensed in the surrounding liquid." The rate of flow of the liquid has very little influence on the effectivity of the cooling. The second part of Dr. Benedicks' report deals with photographic registrations of the cooling time which under dif-

ferent circumstances is occupied by a steel specimen in passing the interval 700° to 100° on quenching. The cooling time (the reverse of the cooling speed) for the cylindrical steel specimens used is directly proportional to the mass, but almost independent of the free surface area of the specimen. For quenching experiments, in order to obtain a high cooling velocity, it is, therefore, indispensable to use very small specimens, and to prevent them coming into mutual contact during quenching. The third part of the report deals with troostite, and the author's experiments confirm his theory that troostite is a solid colloidal solution of cementite in iron, or, in other words, a pearlite having ultra-microscopic particles of cementite. The fourth part of the report deals with austenite, and the most important fact brought out here, concerning the preservation of austenite in carbon steel is that it requires a high mechanical pressure. It is for this reason that austenite never occurs in the outer layer of a hardened specimen under ordinary conditions.

Hardness of the Constituents of Iron and Steel.—Mr. H. C. Boynton has determined the hardness of the different constituents of iron and steel, hardness being defined as the power to resist penetration by a rapidly revolving diamond point. Ferrite has about the hardness of fluorite, pearlite is close to that of apatite; sorbite varies between apatite and quartz; troostite in the specimen tested is a little softer than quartz; austenite is about the same as quartz. The second part of Mr. Boynton's report deals with the hardening effect of "cold working" (especially wire drawing) upon the components of iron and steel.

High-Speed Tool Steel.—From Mr. C. A. Edwards' report on the function of chromium and tungsten in high-speed tool steel, it appears that the function of chromium is to impart to the alloys—when cooled from very high temperatures—a high degree of hardness, and increase the resistance to tempering. This result, however, is only possible when the necessary amount of tungsten or molybdenum is present.

Iron, Carbon and Sulphur.—Mr. Donald M. Levy deals with the influence of sulphur, as it affects the relations of carbon and iron. The iron-carbon alloys are essentially an iron-carbide series, and the graphitic system does not separate directly as such, but results from the decomposition of separated or separating carbide, which, though stable when in solution, is readily decomposed when free, and in mass, at high temperatures. Carbon in iron passes into solution only as carbide and separates out as such. In cast irons free from silicon and manganese, sulphur up to 0.8 per cent exists as FeS (melting point upward of 1180° C.). Sulphur lowers the melting point of cast iron, i. e., the temperature of separation of the first constituent to solidify (iron containing about 1.5 per cent carbon in solid solution—austenite) which separates out free from sulphur. The sulphur concentrates in the mother-liquid and separates at a temperature of 1130° C., together with, and as a component of, the austenite-cementite eutectic, forming a triple austenite-cementite-sulphide eutectic, the cementite component being interstratified with a jointed pearlite-sulphide one. The temperature at which this eutectic separates is slightly lowered as the sulphide increases toward 0.8 per cent. With sufficiently prolonged cooling, the components of the eutectic areas tend to ball up and run together; in sulphur-free irons this secondary segregation proceeds with great rapidity at temperatures about 1130° C.; the massive cementite thus produced is decomposed rapidly at these temperatures and grey irons result. The presence of iron sulphide in the eutectic introduces intervening layers, which may partly ball up, but even then leave sulphide films between the cementite crystals; these act as emulsifiers, preventing the coalescence which is a preliminary to the decomposition of the carbide, and the iron tends to remain white.

Iron and Phosphorus.—Mr. B. Saklatwalla reports on the different compounds of iron and phosphorus, their preparation and the investigation of their constitution by thermal and metallographic methods and hardness tests.

Hardened Supersaturated Steels.—Mr. E. Hess reports on the microscopic features of hardened supersaturated steels. He believes Howe's theory to be correct, viz.: that the supersaturated steels at temperatures above the critical range consist of austenite. Austenite is stable above the critical range, but in slow cooling through the critical range it tends to split up into ferrite and cementite. The rate of cooling governs the extent to which this reaction is completed.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Induction Furnace.—O. Frick, 893,618, July 21, 1908. Application filed Nov. 16, 1905.

The patent refers to the construction of the cover of the annular melting chamber of an induction furnace. This is rotatably supported so that it is possible to observe all parts of the melting space and to charge the same uniformly through a single or some few openings. The cover consists of a single piece so as to obviate cross-joints, the tightening of which always is connected with great difficulties.

Induction Furnace.—K. A. F. Hiorth, 889,522, June 2, 1908. Application filed Jan. 2, 1908.

The melting chamber of an induction furnace is made of spiral-shape, so as to consist of several turns. The two ends of the spiral are connected together by "a conductor of solid or liquid material." In the latter case the ends of the inner and of the outer convolutions of the channel are connected together by a depression passing under the intermediate portions of the channel. If connection is made by means of a solid conductor we have a combination of an induction- and electrode-furnace.

Siloxicon Articles.—E. G. Acheson, 895,531, Aug. 11, 1908. Application filed July 2, 1906.

In order to protect crucibles, twyers, brick, muffles and other articles of carbon from destruction at high temperatures in the presence of oxygen or when exposed to molten metals, Mr. Acheson protects them with a coating of highly refractory siloxicon. This prolongs the life and prevents disintegration or destruction. A portion of the carbon on the surface of the articles themselves is utilized in producing the siloxicon coating, so that a homogeneous article is obtained. The carbon or graphite article, after having been formed, is embedded in a mixture of silica and carbon in the proportion of 2 SiO₂ to 5 C and exposed to the proper temperature at which silicon, oxygen and carbon combine to form siloxicon.

Electrolytic Processes.

Electrolytic Production of Hypochlorite.—W. P. Digby, 892,983, July 14, 1908. Application filed Sept. 18, 1906.

In most electrolytic processes for the manufacture of hypochlorite solutions, the anodic and cathodic products are allowed to react in the main body of the electrolyte, with the result that a complete decomposition of the chloride within the electrolyte becomes an impossibility, and "it is rarely that more than one-fourth of the chlorine initially present in the form of chloride becomes converted into available chlorine in hypochlorite form." Mr. Digby, who has paid much attention to hypochlorite processes, endeavors to prevent this waste of unconverted chloride by letting the reaction between anode and cathode products go on in a compartment where one of the products is liberated in nascent condition. A separate porous cell or suitable partition around both the anode and cathode plates may be employed. A very small space is left between the surface of the electrode and the inner side of its porous cell. Water or water containing caustic soda or sodium carbonate is fed into the cathode cells. From the cathode cells this liquor, much enriched by the alkaline products liberated at the cathode, is passed through a suitable cooling arrangement and is led into the anode cell where it is passed along a zig-zag course over the surface of

the anode and between the anode and its cell. Here it absorbs the chlorine gas liberated at the anode, the result being that the caustic alkali solution is decomposed to form hypochlorite, which is led off for use. The anode and cathode may be artificially cooled, for instance, by making them hollow and letting ammonia expand in the same.

Diaphragm.—F. A. Decker, 895,732, Aug. 11, 1908. Application filed Feb. 11, 1905.

The diaphragm, Fig. 1, shows four sections, 1, 2, 3 and 4, of porous earthenware or carbon, "sealed together on the lines 5-5 and 6-6 by means of the registering, parallel, angularly arranged grooves or sockets 7-7, having rubber 8 packed and vulcanized therein, and the registering, parallel, angularly arranged grooves or sockets 9-9, having rubber to be packed and vulcanized therein." The joints are made by clamping the sections firmly together in registration after the corresponding grooves have been packed and then heating the plate. The several sections are provided with the bordering flanges or ribs 1', 2', 3' and 4' for strengthening and spacing the structure, and with the strengthening ribs 1'', 2'', 3'' and 4'' joined together so as to support the "thin porous diaphragm body produced preferably by removing part of the original body." If a number of such diaphragms are arranged in parallel position to bring the bordering flanges together in registration, compartments are formed.

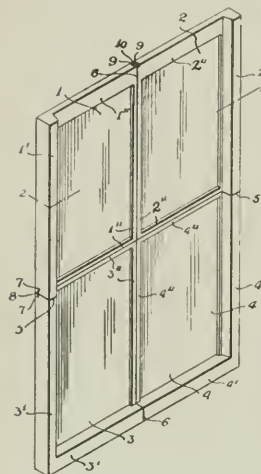


FIG. 1.—DIAPHRAGM.

together in registration, compartments are formed.

Electrodeposition of Copper.—Sherard O. Cowper-Coles, 895,163, Aug. 4, 1908. Application filed May 20, 1907.

Copper having the properties of hard-rolled copper of high tensile strength and free from porosity can be deposited at a rapid rate by revolving the cathode at a peripheral speed of 1500 to 2000 feet per minute when employing a current density of 200 amperes per square foot of cathode surface and an electrolyte containing 12.5 per cent of copper sulphate and 13 per cent of sulphuric acid at a temperature of 40° C. The tensile strength of the copper produced increases with the increase of the speed of rotation of the cathode above 1500 feet per minute.

Chromic Acid from Chromic Sulphate.—G. Adolph and A. Pietzsch, 895,930, Aug. 11, 1908. Application filed April 27, 1907.

The patent refers to the recovery of chromic acid from the liquors containing chromic sulfate which are obtained in the well-known process of oxidizing organic compounds by means of chromic acid. In former electrolytic processes of this kind diaphragm cells were always used, for the reason that no means other than the interposition of a diaphragm between the electrodes were available for protecting the chromic acid formed against the reducing action of the hydrogen set free. The inventors have discovered that such protection is obtained by the presence in the chromic sulphate solution of certain alkaline salts, namely, alkaline sulphates or alkaline acetates and mixtures of both. This effect of their presence in the chromic sulphate solution is due on the one hand to a reduction of the cathodic potential. On the other hand, alkaline bichromate is formed as the main oxidation product and this opposes a greater resistance to the reducing action of the nascent hydro-

gen than chromic acid, and, moreover, does not react with free acetic acid and dilute sulphuric acid in the absence of heat. A numerical example is given as follows: "The electrolyte is composed so as to contain 400 grams per liter chromic sulphate ($\text{Cr}_2(\text{SO}_4)_3 + \text{aq.}$), 150 grams per liter sodium sulphate ($\text{Na}_2\text{SO}_4 + \text{aq.}$), 150 grams per liter sodium acetate ($\text{NaC}_2\text{H}_3\text{O}_2 + \text{aq.}$). This liquor is electrolyzed by means of lead electrodes, applying a current density of 200 amperes per square meter at the beginning up to 2000 amperes per square meter, according as the per cent of chromic acid increases in the electrolyte. In this way about 100 grams per liter of chromic acid will be obtained and 90 per cent of the electric current utilized."

Batteries

Diaphragms.—F. A. Decker. See abstract above under electrolytic processes.

Bromine Battery.—W. Morrison, 892,908, July 7, 1908. Application filed Aug. 11, 1902.

The first claim reads as follows: "In a storage battery, the combination with a cell of non-conducting material, negative and positive elements, the negative element being imperforate, a deposit of bromine supported entirely by the negative element, and means for preventing the deposit of bromine from being displaced from its support."

Bromine Battery.—W. Morrison, 895,060, Aug. 11, 1908. Application filed Aug. 11, 1902.

The first claim reads as follows: "In an electric battery in which bromine is utilized, a cell having a carbon bottom serving as the negative element, the battery being so constructed that the deposit of bromine is held by gravity upon the upper surface of the bottom of the cell, said upper surface being the negative element."

Secondary Battery.—R. J. Fleischer, 888,602, May 20, 1908. Application filed April 8, 1907.

The first claim reads as follows: "A secondary battery comprising a partitioned jar having an upper outer flange below its rim, a cover having a continuous underside groove engaging the rim and a groove engaging each partition, packing in the grooves opposing said rim and partition, and means for holding said cover in detachable connection with said flange."

Storage Battery.—T. A. Willard, 888,951, May 20, 1908. Application filed March 29, 1907.

The first claim refers to "a battery plate consisting of a one-piece blank having rows or stripes of projecting ribs alternating with rows or stripes of flat spaces arranged on opposite faces of the plate and having oval openings arranged crosswise of the ribbed stripes and out of alignment with each other."

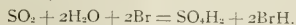
Storage Battery.—G. A. Ford, 895,449, Aug. 11, 1908. Application filed Oct. 27, 1905.

The first claim refers to "a storage battery unit consisting of a tray molded from paper pulp having a reinforced upturned marginal flange, a bottom which inclines upward from a central point towards said flange, and integral bosses extending downward from the bottom of said tray, and an electrode in said tray."

Regenerative Battery.—L. P. Basset, 895,715, Aug. 11, 1908. Application filed March 27, 1906.

This invention refers to a double-fluid battery with carbon electrodes, and the essential feature is that the electrolyte resulting from the discharge of the cell can be regenerated simply by heat. The construction of the cell is shown in Fig. 2, representing a vertical and horizontal cross-section. The electrodes, 10, of carbon form a series of compartments, each of which is divided into two parts by a porous partition wall 11. The two groups of compartments, 12 and 13, thus obtained are in communication alternately by branching pipes 7 and 8. In the compartments, 12, the first electrolyte is caused to circulate, composed of sulfurous acid added to a dilute solution of sulfuric acid, and in the second group of compartments, 13, the other electrolyte, composed of bromine and dilute sulfuric

acid. "These two electrolytes come into contact by passing through the porous partition, 11, and react on each other according to the formula,



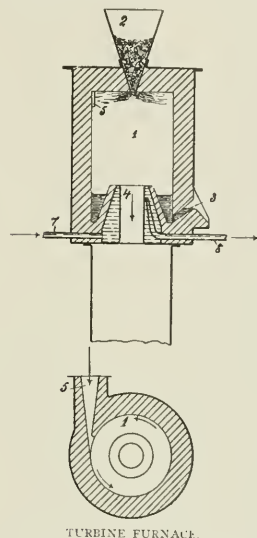
In this reaction, due to the presence of the porous partitions, an oxidation of the sulfurous acid is produced so as to form sulfuric acid, and the bromine combines with the hydrogen of

as to retain the bottom portions of their contents in cool condition.

Iron and Steel.

Turbine Furnace.—We have repeatedly pointed out how in Mr. C. G. P. de Laval's inventions—from the big steam turbine to the small cream separator—the rapid rotary movement is of pre-eminent importance. He applies it in his zinc furnace and has suggested it for iron reduction. In a recent patent (885,766, April 28) he proposes to use the same principle to obtain a violent chemical reaction between materials in general. Naturally this is best possible with finely powdered and intimately mixed materials. The furnace for applying this principle is shown in the adjoining illustration. 1

is the cylindrical furnace chamber with the hopper 2 for introduction of the pulverous charge. In the lower part of the furnace is an outlet 3 for the molten charge and a central outlet 4 for the gases of reaction. Opening into the upper part of the furnace is the contracted mouth of a tangentially arranged pipe or nozzle 5 for air or gas which enters into the furnace with great velocity and rapidly whirls or rotates within the furnace, carrying along with it the pulverous charge introduced through 2. The gas moves in a spiral direction from the circumference to the central line of the furnace toward the exit 4. On the other hand, the charge moves in a spiral direction from the center 2 to the circumference of the furnace.



TURBINE FURNACE.

The application to the extraction of iron is as follows: The charge consists of iron ore, slag forming materials and carbon, which is burnt to CO in the upper part of the furnace. The gas introduced through 5 consists of carbon monoxide or of air, which if desired may be mixed with carbon so as to form carbon monoxide within the furnace. The molten metal and slag are withdrawn through 3. If it is desired to establish an oxidizing zone in the lower part of the furnace a tangentially arranged pipe may be provided below 6, through which air is blown into the furnace so as to burn the CO₂ formed in the upper part of the furnace, to CO₂.

Thermit Process.

Reduction of Chromium.—In the application of the well-known Goldschmidt aluminothermic method to the production of carbon-free chromium, the oxide Cr₂O₃ has been employed in the past. Its disadvantage is a comparatively small output of chromium due to the slowness of the reaction. If on the other hand a higher oxide of chromium is mixed with aluminium, the reaction is too quick and is rather turbulent and involves danger and loss of metal. According to Hans Goldschmidt and Otto Weil (895,628, August 11, 1908) these disadvantages can be overcome and the output of metal increased by about 30 or 40 per cent, if a small amount of a higher oxide (for example 1 per cent of chromic acid) is added to Cr₂O₃. This addition serves as a stimulant for quicker reaction and at the same time causes the formation of an easily melting slag. A suitable mixture consists of 100 kilograms of pure Cr₂O₃, 3 to 4 kilograms of chromic acid and 34 to 35 kilograms of finely granulated aluminium.

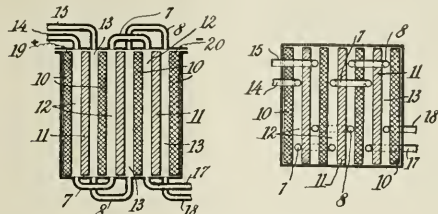


FIG. 2.—REGENERATIVE BATTERY.

the water to form hydrobromic acid. It is this reaction which produces a current of 0.63 volt, which is collected at the terminals 19 and 20." With the aid of a pump the liquid which comes out of the two groups of compartments is forced through a common passage into a suitable heating apparatus or regenerator in which the hydrobromic acid and sulfuric acid are decomposed into bromine, sulfuric acid and water. The two electrolytes above mentioned containing the bromine and the sulfuric acid come out separately from the regenerator, and the course of the operations is continuous.

Discharges Through Gases.

Fixation of Atmospheric Nitrogen.—A. J. Petersson, 889,857, June 2, 1908. Application filed April 13, 1906.

The furnace contains a reaction chamber with a central electrode and a ring-shaped or spiral-shaped (screw-shaped) electrode surrounding the latter. The discharge between the two electrodes takes place radially through the mass of air or gas moving axially. Around the reaction chamber excitation devices are provided for creating in the reaction chamber a magnetic field of axial direction. "By the said arrangement of the electrodes and the magnetic field in relation to each other, it will be possible to obtain the power, by which the arc is placed, proportional or approximately proportional to the length of the path that each part of the arc has to run, whereby the various points of the arc will be displaced at the same angular velocity, thus obviating the risk of the arc being disrupted."

RECENT METALLURGICAL PATENTS.

Zinc.

Zinc Refining.—It has long been known that zinc may be separated from metals of greater specific gravity by reducing the spelter to a molten condition and allowing the heavier metal to settle out. The zinc, under these conditions, may be distilled at a temperature which will not affect the heavier metal, although in practice it is found that the process is frequently accompanied by the distillation of appreciable percentages of the contaminating metal or metals (lead, zinc, etc.). R. Ziesing (893,415, July 14, 1908) overcomes this difficulty by directing heat against the retorts from above, and shielding those portions of the retort containing the lead and silver from any direct heat. The body of contaminating metal thus remains quiescent, while the other portions of the retort are raised to a sufficiently high temperature to maintain rapid distillation of the zinc. The process is carried out in a down-draft furnace, in which the retorts are disposed upon beds or supporting pillars of non-conducting material. Specially formed retorts are employed so

National Waste.

By OSKAR NAGEL, PH.D.

The present industrial depression has caused a widespread pessimism as to the future earning capacity of our industries. Though we all know that we have still immense deposits of minerals, ores and fuels that have hardly been touched, there is a certain uneasiness, because for opening up these deposits capital will be required, which can only be obtained from the profits of the industries already in existence.

Hence it is of the most vital interest to ascertain ways and means of conducting our industrial operations in a more economical way. If we look over our iron, coke and other industries and remember certain improvements which have been in successful use in Europe for the last eight to ten years, we will have no difficulty in arriving at some valuable conclusions.

All industries are based upon the consumption of fuel, and since our coal deposits are by no means unlimited, it is obvious that fuel economy is of the greatest importance to the nation. Hence we will first consider the waste of fuel in our main industries and the methods to prevent this waste.

According to the census of manufactures about 16,000,000 tons of pig iron were produced in the United States in 1905 in blast furnaces in which heated air (hot blast) is blown through the ore, coke and limestone, contained in the furnace in alternate layers. In this process the air, by going through the charge, is transformed into a combustible gas, called blast furnace gas, which leaves the furnace at the top.

A very large part of this valuable gas, which is well adapted for fuel purposes and exceedingly fit for driving gas engines, is going to waste in the United States, while in Europe every bit of it is utilized. From the 16,000,000 tons of pig iron produced, about 225,000,000 cubic feet of blast furnace gas are obtained, half of this quantity being used for heating the air blast. Of the other half hardly one-third is used, the rest going to waste. If we express this waste in horsepower that could be generated by its combustion in gas engines, we find that over 800,000 horsepower are continuously wasted for 24 hours of every day in the year. According to the price asked at Niagara Falls for one horsepower per year, which is \$15, this "wasted rest" is equivalent to a yearly loss of \$12,000,000. Even according to the lowest cost that waterpower can be produced for under most advantageous conditions (in Norway), which is \$5 per horsepower per year, the annual loss amounts to \$4,000,000. A first start for utilizing this waste gas in the United States was made a few years ago by the Lackawanna Steel Company, and now the United States Steel Corporation is taking steps in the same direction, but still it will be many years before we will completely do away with this waste.

The coke industry affords another instance of wasteful operation. The manufacture of coke is very similar to the manufacture of illuminating gas (coal gas); in the latter coke is obtained as a by-product of the gas manufacture, while in the former gas is obtained as a by-product of the coke-making. In Europe nearly all the coke-oven gas produced is utilized, while in this country 90 per cent. escapes into the air as a waste. According to the Mineral Resources of 1905, the gas obtained in the manufacture of 32,000,000 tons of coke was wasted. This quantity of gas is sufficient to continuously develop 700,000 horsepower throughout the year and hence has a fair value of \$10,500,000 and a minimum value of \$3,500,000. We now see that the combined iron and coke industries are wasting continuously at least 1,500,000 horsepower in a manner which forever prevents the reclamation of this waste and hastens the exhaustion of our coal deposits.

A similar waste of fuel prevails in the smaller industries. I know of power plants owned by large and wealthy corporations in which 7 to 10 pounds of coal are burned to produce one horsepower per hour, while not more than 3 pounds should be consumed in a good steam plant. This shows that by using modern machinery the drain upon our coal mines will be con-

siderably reduced. According to the results of modern engineering science the use of steam power is extremely wasteful, if the heat of the exhaust steam is not or cannot be utilized.

Hence for such installations in which power is to be produced exclusively, the gas engine in connection with the so-called gas producer is the most economical means for developing power, one horsepower being produced by this system for one hour from one pound of coal. The gas producer is an ordinary stove containing a high layer of incandescent fuel, which is transformed by the air drawn through into a combustible gas called producer-gas. The manufacture of this gas is chemically nearly identical with the gas formation in the blast furnace, the latter being, in fact, a huge gas producer.

We are wasting fuel in an incredible manner. We allow power equivalent to the capacity of several Niagara Falls to escape into the air, while we see that the European nations are utilizing the fuel three times as economically as we do and are successfully using such low-grade materials as lignite and peat, which we do not seem to want to touch before we have to.

Another national waste, and undoubtedly the worst and most dangerous, is the reckless drain upon our forests. It is our fault that wood is getting scarcer and more expensive every year. According to a report of the Department of Agriculture the estimates of standing timber range roughly from 1400 to 2000 billion ft. Assuming a stumpage of 1400 billion ft., an annual use of 100 billion ft., and neglecting growth in the calculation, the exhaustion of our timber supply is indicated in 14 years. Assuming the same use and stand, with an annual growth of 40 billion ft., we have a supply for 23 years. Assuming an annual use of 150 billion ft., the first supposition becomes 0 years and the second 13 years. Assuming a stand of 2000 billion ft., a use of 100 billion ft., and neglecting growth, we have 20 years' supply. Assuming the same conditions, with an annual growth of 40 billion ft., we have 33 years' supply. With an annual use of 150 billion ft., these estimates become, respectively, 13 and 18 years.

As, considering the drain upon our forests, the annual consumption of wood is probably three times the annual growth, it is evident that something has to be done for increasing the yield of our forests. For this purpose the principles of forestry have to be applied, which rest on natural laws.

Let us see what forestry has done in Germany. Starting with forests, which were in as bad shape as many of our own, which had been recklessly cut over, it raised the average yield of wood per acre from 20 cu. ft. in 1830 to 65 cu. ft. in 1904. During the same period of time it trebled the proportion of saw timber got from the average cut, which means, in other words, that through the practice of forestry the timber lands of Germany are of three times better quality to-day than when no system was used. And in 54 years it increased the money returns from an average acre of forest sevenfold. Yet to-day the forests are in better condition than ever before, and under the present system of management it is possible for the German forester to say with absolute certainty that the high yield and large returns which the forests now give will be continued indefinitely into the future.

There are many other products that go to waste as, for instance, the garbage of our cities. The utilization of the blood in our stock yards is extremely crude, while in Europe a very valuable product, blood albumen, is extracted from the blood. The utilization of our various ores and minerals is also far from reaching the European economy.

Up to this time our engineers were mainly striving for a reduction of the cost of production by replacing manual work by machine work. Immense savings have thereby been effected and America has become the leading industrial country. For retaining this position it is imperative to also consider all possible savings that can be made in raw materials. By means of our ingenious mechanical appliances we are enabled to fully utilize the capacity of our workmen. It is now about time that we also utilize our raw materials in a scientific way.

Mercury Ammeter for Large Currents

Considerable difficulty is experienced in making exact measurements of strong alternating currents, considerably exceeding 1,000 amperes, such as are used in electric furnaces for electric welding, etc.

In practice, these large currents are measured with the aid of a series transformer. The ratio of the transformer is computed and its small secondary current is measured by an alter-

ing in a difference of hydrostatic pressure between the axis and the circumference of the conductor. This difference in pressure in a conductor of circular cross-section is numerically equal to the square of the current strength and inversely equal to the cross-sectional area of the conductor.

If the conductor is made up of two or more liquid portions in circuit with solid portions the differences in pressure set up by the passage of the current in the liquid portions may be added, like electromotive forces, in series and the resultant pressure difference utilized to raise a column of liquid. This raised liquid column may be used to directly measure the value of the current, or the motion of the raising column can be communicated to any style of pointer moving over a scale or dial.

The liquid found to be best adapted to use in the construction is mercury. The height to which the mercury column will rise with a given current may be magnified for convenience of observation, but not for accuracy, by causing the pressure to be transferred to a column of colored water. Further description of the mechanical features of the apparatus is made unnecessary in view of the accompanying illustrations.

In practice it is found necessary to use two mercury pockets or cells and to make these but 1/64th of an inch in their axial dimension. On account of their short length and the proximity of massive copper blocks to rapidly conduct away the heat, great current densities may be passed through the cells. In fact 20,000 amperes to the square inch gave a rise in temperature in the cell as measured by a thermo-couple of only 16° C.

Mercury has sixty times the resistance of copper, and hence, if this latter metal were to replace the mercury, current densities of 1,200,000 amperes per square inch under like conditions could be passed through the short conductor. It may also be shown that keeping the axial length of the cells always the same, the number of watts required to raise a column of water a given height is independent of the number of mercury cells used and the current passing.

It is found that approximately 1.4 watts is required for every inch rise of water. Hence, as an ammeter properly constructed

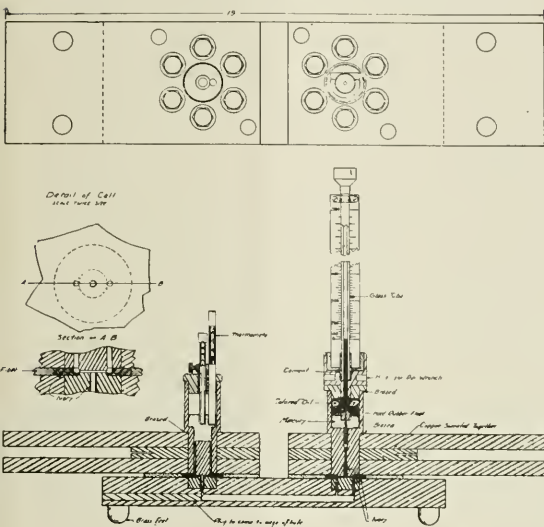


FIG. 1.—SECTIONS OF MERCURY AMMETER.

nating-current ammeter which has been accurately checked by any of the well-known methods. The large primary current is then known as accurately as the calculated ratio of transformation of the series transformer.

A true and accurate value of the ratio of a series transformer cannot, however, be obtained by computation. The ratio should be obtained experimentally, under the conditions of frequency, wave form and load, in which the transformer is to be used to get an accurate determination of the heavy primary current from a precise measurement of the small secondary current.

There is, therefore, need of a standardization instrument, of not excessive cost, which can be inserted directly in an alternating-current circuit, carrying any current over 1,000 amperes, and which will measure this current with the same precision as small alternating currents are measured. The first simple and inexpensive instrument which answers this purpose is the mercury ammeter designed by Dr. E. F. Northrup and described by him in a Franklin Institute paper (which may be found in full in the August issue of the *Journal* of this Institute). The instrument is of special interest to the readers of this journal since in principle it is based on the "pinch effect" which was first discovered by Carl Hering (this journal, Vol. V, page 223), while its theory was fully worked out and various applications made of it by Dr. Northrup himself (*Phys. Rev.*, July, 1907).

The adjoining illustration shows a mercury ammeter suitable for measuring 2,000 amperes alternating current. The action of the instrument depends upon the essential principle that when a current, direct or alternating, passes through a conductor, there is set up in the conductor an attraction towards its axis of all the imaginary elemental filaments of the conductor. This attraction, when the conductor is a liquid conductor suitably confined in an insulating tubular space, results

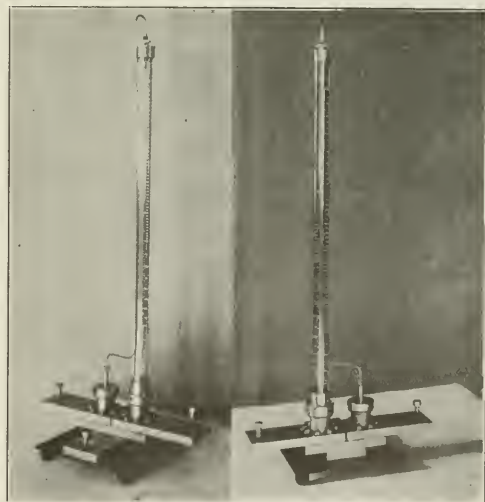


FIG. 2.—MERCURY AMMETER.

can be easily made to dissipate 33 watts, it can be made to give a scale, using water, 25 inches high.

When, however, water is used, the instrument has a temperature error of 1/2 per cent per 10° C., as this represents the in-

crease in the lightness of the water which expends one part in four thousand for every degree Centigrade. For precision work the error may be calculated and allowed for, as the temperature is easily measured. If water is not used the rise in the mercury column may be directly observed with a cathetometer or microscope, in which case the possible precision is very high.

The indications are absolutely the same with direct and alternating currents and strictly follow the square law. It is proposed to carefully construct a large mercury ammeter with all its dimensions carefully measured and to employ it in the absolute determination of current.

The mercury ammeter may, if desired, have its constants obtained at one point on the scale by passing a large known storage-battery current through it; the remainder of the scale may then be laid off by calculation and the instrument is then adapted to give precise measurements of large alternating currents. By inserting this instrument in series with the primary of a series transformer of large capacity to measure the primary current and by measuring at the same time the secondary current with the A.C.-D.C. Comparator, or any instrument which has been checked by it, the ratio becomes accurately and experimentally determined. The series transformer with its constants determined in this manner becomes then a truly valuable adjunct in the measurement of large alternating currents. It only remains to determine the phase relations existing between the primary and secondary currents of the transformer to make of it a precision piece of apparatus.

The useful lower range of the mercury ammeter has not yet been fully determined, but though a 500-ampere instrument is easy to construct, there would be little demand for instruments of similar capacity, as below this precise null methods are available.

Fig. 2 gives two outside views of a mercury ammeter which reads from 300 to 1,400 amperes without using less than one-fifth of the scale at any time. The two photographs are two views of the same instrument. The right-hand photograph is a front view of the instrument and the left-hand photograph is a back view of the instrument.

In the latter it will be noted that there are three terminals. When connection is made to the two end terminals, the two cells of the instrument are thrown in series and give a scale of one value. When the left-hand terminal and the middle one are connected, but one cell is used giving a scale of another value. When the right-hand terminal and the middle one are connected, a third scale is obtained having still another value, the two cells being of unequal size.

In this way the instrument may give a number of scales in the same manner as a current dynamometer may give a number of scales by having different windings of the fixed coil which can be connected in by joining to different binding posts.

The small metal tube reaching from the top of the scale tube to one of the cells is an improvement made since the Franklin Institute paper was written, serving the purpose of excluding the external air and preventing the colored water, used in the instrument, from evaporating.

The Leeds & Northrup Co., of Philadelphia, build these instruments to order if the minimum current required to be measured is not too small, say 500 amperes. The maximum current that can be measured with this instrument may be anything.

This instrument, being based in an ingenious way on a new principle, represents certainly one of the most interesting developments in electrical instrument design and should prove very useful especially in the hands of electrochemists and electrometallurgists.

Disinfecting Liquid.

Electrolytic production of hypochlorite solutions for disinfecting purposes is old and well known. While various com-

mmercial attempts made in this country have not led to a permanent installation, much interest has been taken in England in recent years in processes of this kind, and we have had occasion to refer repeatedly especially to the Hermite process. Thanks to the efforts of the Medical Officer of Health its use has been largely developed in the Metropolitan Borough of Poplar, where it is prepared by a private plant, and it has also been employed at many other large establishments in England, among them the Royal Military Hospital at Netley.

According to the London *Electrician* of July 31 a commercial plant for manufacturing this disinfecting fluid has been erected. This solution is called "Thalassol," to suggest the possibility of making it from sea water (thalassa being the Greek word for Ocean). In practice, however, an artificial solution of magnesium and sodium chlorides is used, since it is exceedingly cheap to prepare and it is free from organic matter. Further, if sea water is used the solution obtained is not always of uniform strength.

The cells in which electrolysis takes place contain electrodes of zinc and platinum, arranged in tiers so that the electrolyte can flow over them. In this particular case 40 cells are arranged in series, and the necessary current is supplied from a small motor-generator coupled to the supply company's mains.

According to a Faraday Society paper of Biggs, the electrolytic process "consists in the electrolysis of the magnesium chloride solution, the sodium chloride acting simply as a carrier, hydroxide of magnesium and chlorine being the products. It is stated that the latter combines with the oxygen of the water to form oxides of chlorine, which constitute the vehicle for the bleaching action, and not merely hypochlorite. To the solution thus formed is added a special alkali, and is transferred to carboys with repeated stirring."

Thalassol is non-poisonous and is sold in ordinary bottles. In spite of the fact that it contains chlorine when quiescent, it is nearly odorless and quite pleasant to smell. It gives off chlorine when in action, especially when attacking organic matter. In certain parts of England it is said to have become quite a household article, being used for such wide-apart objects as brushing the teeth and washing the floors. It is a great advantage in laundry work and is said to be excellent for removing stains.

What a Manufacturer Should Know About Coal.

At the annual meeting of the National Association of Cotton Manufacturers in Boston, Mr. E. G. BAILEY discussed "some things a manufacturer should know about coal." This address has been published as No. 3 of the serial of professional papers of members of the staff of the Arthur D. Little Laboratory of 93 Broad Street, Boston.

The manufacturer should first consider where he can always get coal when he needs it. There is a possibility of strikes or of delays in transportation and in placing a contract this point should be kept in mind and whenever the difference in price is not too great, preference should be given to the company that is most able to keep its customers supplied with coal at such exceptional times.

If the plant is at a great distance from the mine, storage of coal becomes necessary and this involves considerable expense. There are many theories as to the cause of spontaneous combustion in coal piles and several remedies have been tried with more or less success. It seems that the rate of circulation of air through a coal pile has more to do with this question than any other condition outside of the character of the coal.

Other important points which a manufacturer should consider are where he can get coal of such character and quality that his plant will not be crippled for lack of steam and further what coal is the most economical for him to burn.

Coal varies more in character and quality than any other mineral produced. In character it is found in all successive

stages between lignite and anthracite. Each different kind is more applicable for one purpose than another.

In selecting a coal for making illuminating gas the illumination obtained from the gas measured in "candle feet" is of primary importance, while the coke and tar are by-products, and sulphur is the impurity that causes additional expense.

For making coke the purity, structure and yield of coke are the properties to be considered, and the gas, tar and ammonia may be utilized as by-products.

In buying steam coal the amount of heat that may be developed from it is the measure of its value to you. There is no byproduct that may be utilized, except that in some cases the scale of ashes might be considered in this connection, but their removal is generally an additional expense. Two coals at the same price and containing the same number of heat units may not be equally desirable. The difference in volatile matter might cause the lower to prove more satisfactory under certain conditions of smoke restriction, while the higher volatile coal would probably be more applicable in a plant with fluctuating load. The amount and nature of ash in regard to the formation of clinker often needs to be considered.

The liability of spontaneous combustion of one coal more than another may make it advisable to pay several cents per ton more for one coal containing no more heat units than the other.

The following table shows the analyses and results of evaporative tests of some of the better coals together with their price f. o. b. cars at the plant of the inland New England mill. The relative values have been calculated by taking coal A as a basis and determining what will be the cost of the equivalent amount of coal required to produce the same number of heat units as coal A produces for \$4.60 per ton. For example, should one buy coal F at \$4.40 per ton the coal bill would amount to the same as if he had bought coal A and paid \$4.92 per ton for it, but as he can get coal A for \$4.60 per ton would save 32 cents per ton by taking coal A instead of coal F at the given prices.

In this case it appears that neither the best nor the lowest priced coal would be the cheapest to buy.

	Mois- ture.	Vola- tile.	Fixed car- bon.	Sul- phur.	B. t. u.	Lbs. water evaporat- ed and at 212° F.	Price f. o. b.	Relative cost per ton with Coal A as basis	By evap- b. t. u. oration.	By
A	1.25	17.94	73.15	7.66	0.07	14,354	9.93	\$4.60	\$4.60	
B	1.43	17.59	71.58	9.40	1.09	14,032	9.73	4.53	4.65	
C	1.17	30.51	61.01	7.31	0.99	14,251	9.79	4.65	4.60	
D	1.36	16.42	71.35	10.87	1.77	13,811	9.60	4.58	4.76	
E	1.75	19.58	71.95	6.72	0.82	14,533	10.93	4.86	4.80	
F	3.72	21.06	66.99	8.32	1.36	12,834	8.80	4.40	4.92	
G	1.74	31.16	53.68	13.42	2.93	12,833	8.67	4.60	5.14	5.27

In this table the coals are arranged in order of cost for equal amounts of heat generated and equal evaporation, but in selecting a coal for any particular plant it might be policy to select a coal that would cost a little more money in order to obtain some particular advantage that a certain coal might have over another.

Comparing coals A and B, coal A appears to be better in every way except that it contains about 1 per cent more sulphur than does B. For steam purposes the sulphur is of little importance below 2 per cent, at least, so that coal A would probably be selected on account of its being 5 cents per ton cheaper on a heat-unit basis and there would also be less ash to handle.

In case a plant had limited draft and boiler capacity a coal like C might be selected in preference to B, or even A, with a difference of 9 cents per ton in favor of coal A.

Should the prevention of smoke be an item of considerable importance, coal D would probably be purchased at an additional expense of 7 cents per ton, as compared with coal C. Of the two coals D and E there is a difference of only 4 cents per ton and that would scarcely pay for the additional cost of handling ashes, the possibility of not being able to carry the load without the use of more boilers, and other expenses that are greater with a poorer coal.

While coal F is the best all round coal, it would pay to pur-

chase it, while coal A could be obtained for 20 cents per ton cheaper on a heat-unit basis, and 19 cents per ton cheaper on an evaporation basis.

Coals F and G are both much inferior to the others and their purchase would not be considered when any of the other coals were available at the given prices. Judging from the ash and sulphur alone, it would seem that coal F would be better than either B or D, but a certain characteristic appears in this coal that makes it different from any of the others. It is "crop" or "red" coal coming from a part of the seam near the outcrop and has become saturated with the surface that has been percolating through it for hundreds of years.

The moisture is much higher than in any of the other coals and it contains a still larger percentage of combined water that is not driven off by the mere drying of the coal. If a man were depending upon the ash determination alone he would never detect that he was receiving an inferior quality of coal; in comparison with coal A he would be paying 20 cents per ton less for the coal, yet he would have to burn so much more of it to develop the same horse-power that he would actually be losing 32 cents per ton, or \$16,000 per year on a 50,000-ton contract.

Coal G is high in ash and sulphur and correspondingly low in B.t.u., so that it would be a very expensive fuel to burn at the price quoted, and in comparison with the other coal it should not be considered. Yet there are thousands of tons of it being burned and the manufacturer seems to be willing to pay the price.

In the preceding table the equivalent evaporation in pounds of water from and at 212 deg. Fahr. is given as determined in carefully conducted boiler tests on the same boiler. They represent the average of two or more tests under as nearly identical conditions as it is possible to maintain, thus accounting for the closeness of their comparisons with the B.t.u. determination. Duplicate boiler tests on the same coal frequently vary 5 to 10 per cent, even though the method of firing and the rate of combustion have changed as little as possible.

The chemical analysis and calorimetric determination will represent the value of coal within 1 per cent, providing the samples are properly taken. The plea for evaporation tests because they are practical is counterbalanced by their failure to burn the coal under equally comparable conditions in two or more cases. A fireman must become accustomed to different coals and find wherein they must be handled differently in the firebox in order to obtain the best evaporation from each. The laboratory tests are generally considered as theoretical and unreliable. But theory and practice always agree when they both represent the facts.

After the most economical coal has been sold it remains for the manufacturer to see that this coal is delivered. If the coal company knows that the coal is being systematically analyzed by their customer, this fact is generally sufficient to ensure delivery of coal of uniform quality.

Finally, the manufacturer has to consider how to convert as large a portion as possible of the energy of the coal into useful work. The question of smoke prevention must receive more consideration from the manufacturer in the future than it has in the past.

After combustion has taken place the heat of the coal appears in the form of sensible heat in the gases leaving the furnace or combustion chamber. The important problem is to cool the gases as much as possible with a minimum of boiler heating surface. In order to accomplish this the heating surface should be kept clean inside and out. Too much emphasis cannot be put on this point.

Combustion is more complete with considerable excess air, but this excess air passing through the furnace reduces the temperature of the gases approaching the boiler and the temperature of the escaping gases remains about the same so that a larger percentage of the developed heat is lost up the stack. This condition might be compared with a steam engine running

with low initial pressure and exhausting against a high back pressure.

The amount of air excess is regulated by the intensity of draft and condition of the bed of fuel. Few firemen have ever had the opportunity of learning what was the best thickness of fire or intensity of draft under certain kind of coal. Many people think the stronger the draft the better, but there is opportunity to save thousands of dollars every year in many plants by merely reducing the draft or by better regulation of it. The installation of a damper regulator is not always the remedy, for they often cause more loss than occurred when hand-regulated dampers were used.

The analysis of the flue gases is the best criterion for regulating the conditions of a furnace so as to obtain nearly complete combustion with a minimum of air excess. The perfecting of automatic gas indicators and recorders will do very much toward increasing the boiler-room efficiency.

No one kind of boilers or heat-absorbing apparatus will give equal satisfaction in all plants. This depends upon location of plant, kind of water, uniformity of load, kind of coal, etc., and must be determined in each individual case.

Refined Copper.

According to a recent press bulletin of the U. S. Geological Survey the production in 1907 of refined new copper of domestic origin was 784,271.427 pounds, a decrease of 103,410,960 pounds, or 13.2 per cent, from the production of 1906. The total output of refined copper (exclusive of domestic scrap, etc.) by domestic refineries in 1907 was 1,032,516.247 pounds.

In addition to this production of refined copper 25,129,617 pounds were recovered during the year by the regular copper-refining companies of the country from domestic scrap, drosses, etc., and returns from practically all the known refiners of secondary materials indicate that 35,355,966 pounds additional were turned out by them as casting copper and in alloys. The copper produced from secondary sources in 1907 was therefore somewhat in excess of 60,000,000 pounds, or more than 7.5 per cent of the year's production of refined new copper.

Returns from all the Lake and electrolytic refiners are practically complete and show the following stocks of refined copper on hand at the beginning and end of the year:

	Pounds.
January 1, 1908.....	125,745,796
January 1, 1907.....	46,497,181

Increase during 1907..... 79,248,615

Undelivered sales are almost entirely excluded from these figures, and stocks carried by consumers and brokers have not been estimated. In addition to these stocks of refined copper there were at the smelters, in transit to the refineries, and at the refineries blister copper and material in process of refining to the amount of 135,319,239 pounds on January 1, 1907, and 175,254,659 pounds on January 1, 1908.

The apparent consumption of refined new copper in the United States in 1907 was about 485,000,000 pounds, as compared with 685,000,000 pounds in 1906, and it is probable that in addition most or all of the 60,000,000 pounds of reworked copper was consumed.

The figures given above are compiled by Mr. Graton from the exact records of all but one known producing company. A comprehensive report on the copper industry in 1907 is in preparation and will be published by the Geological Survey as an advance chapter from "Mineral Resources of the United States, Calendar Year 1907."

Tilting Crucible Furnace.

A new tilting crucible furnace has just been placed on the market by the Rockwell Furnace Company of New York City embodying some decidedly advantageous features, which will

be readily appreciated by the foundryman. As can be seen from the illustrations, the crucible is not removed while pouring the metal from the furnace, but remains fixed and the metal is transferred to the moulds by means of a heated ladle or crucible, as preferred.

The burner, which is operated with a fan blast of but 12 ounces, makes but little noise and uses either oil or gas fuel, being located at the top of the heating chamber and the flame is projected down against the bottom of chamber and not against the crucible, which insures a long life of the same. In case of the crucible breaking the metal is all retained in the furnace and does not run on the floor and the melting may be continued until the metal is at the proper temperature, when it may be transferred to the moulds in the usual way. This feature makes it unnecessary for the foundryman to worry when the crucible becomes thin, or to throw it away before it actually breaks, as is often done, when several heats may still be gotten from it.

As any air pressure from 12 ounces to 2 pounds may be

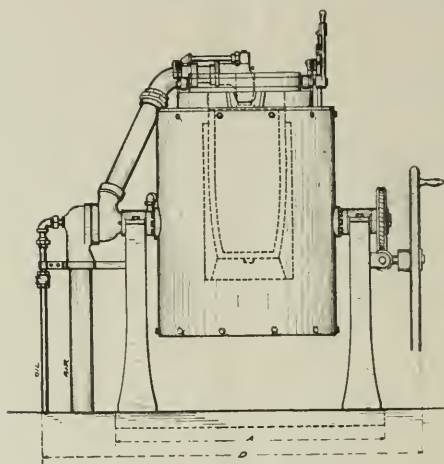


FIG. 1.—SECTION OF TILTING FURNACE.

used, the furnace can be operated from any available air and oil system which may be supplying other furnaces, a separate plant being unnecessary.

The cover is manipulated by a lever conveniently located at the rear of the furnace, from which a pin engages a ratchet and holds the door rigidly in any required position and permits covering the crucible after pouring without returning the furnace to an upright position.

Heavy pieces of metal may be fed to the crucible through the opening in the cover of the furnace while the blast is on. The waste heat passing through melts it down into the crucible very rapidly.

As the crucible is not removed, after the first heat metal is always charged into a hot pot, which greatly facilitates the melting.

Where it is essential that the heated gases in the furnace should not come in contact with the metal, a cover may be put on the crucible to protect same. Although it is unnecessary for ordinary work, as scrap yellow brass stampings from the ends of safety pins have been melted hot enough for pouring very light castings with a loss of but 3 per cent. The only precaution taken while melting was to cover the metal with a few pieces of hard coal.

The number of heats per day will vary from 3 to 10, and the amount of fuel required will range from 1½ to 3 gallons

of oil—210 to 420 cu. ft. natural gas; 315 to 630 cu. ft. illuminating gas; 675 to 1350 cu. ft. 300-B.t.u. water gas, according to the quantity and quality of metal melted, the heat at which the metal is required, and the attention and promptness with



FIG. 2.—TILTING CRUCIBLE FURNACE.

which it is melted and poured. But the above is a fair average.

The furnace is easily relined with simple and inexpensive fire tile.

The furnaces are at present made in four sizes to hold numbers 70, 125, 275 and 450 crucibles respectively. A 32-page catalogue describing this and twenty other styles of melting furnaces has just been issued and may be had from the manufacturers, Rockwell Furnace Co., 26 Cortlandt St., New York.

Screen for Wet Products.

The Traylor Engineering Company, of New York City, have perfected and are manufacturing a new screen for handling fine wet products, which is shown in the adjoining illustration.

The screen surface is octagonal in form, the width of the drum being about 24 in. Each of the eight sections is 18 in. wide in the other direction. The screen cloth is secured to the wooden frames, which are placed in the steel flanges of the drum. An angle is placed over adjoining edges and this is clamped down by means of a key at each end of the angle, as indicated. By this means the frame is very quickly and easily removed and replaced when it is required to change a cloth by merely driving out the keys.

The product to be screened is fed over two distributors provided with fingers for evenly spreading same over the width of the screen; this gives a much more efficient classification than if but one were used.

Each of the screen sections has a compartment in the screen frame running toward the center. The center of this drum is conical, the cone surface sloping outwardly, so that the through product will run out from the drum to the discharge hopper placed on the side of the housing away from the gears. The oversize product remaining on the outside of the screens will, as the drum rotates, fall off into the screen housing in a measure. To effectually clean the meshes of the screen cloth from this oversize material, water spray pipes are provided, each of the eight compartments being furnished with an individual spray pipe, which is connected through the hollow shaft by means of a swivel coupling at its outward end to the water supply. Each of the eight pipes rotating with

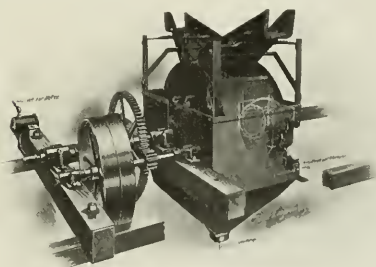
their respective compartments are provided with an automatic valve. These valves are tripped by a cam so that as each compartment nears the bottom position in the revolution of the drum the valve will be tripped. The spray pipe in each of these compartments is perforated so that the entire surface of the screen will be flooded during the time the water is turned on. This connection is so arranged that as each successive compartment of the screen approaches the bottom position in revolution, this flooding takes place and effectually clears the meshes of the cloth of all oversize material.

In order to protect the spray openings from being clogged, a gravity hood or swinging saddle is placed on each pipe. This is weighted so that the angle guard of same is likewise vertical above the pipe and thus prevents the screened product from falling into openings of the spray pipe and clogging the same. As these pipes approach the bottom position where spraying takes place, such angle guards being above the pipe do not obstruct the spray.

The housing of the screen is tapered to a central discharge outlet for the oversize product, and the service of this water used for spraying is very desirable inasmuch as it performs the duty of conveying the oversize products in the launder after leaving the screen, as well as the duty performed in washing the meshes of the screen clear.

The machine takes practically no power to drive it, inasmuch as the weight of the oversize product tends to assist in the rotation of the same. The entire machine is exceedingly simple and when properly set up requires no further special attention for its operation.

Another principal feature of the machine is that it is noise-



SCREEN FOR WET PRODUCTS.

less and revolves slowly at about eight revolutions per minute. The wear and tear is practically nil, except the natural wear of the action of the ore on the screen cloth.

Notes.

The Brown Hoisting Machinery Company of Cleveland have sent us their Catalog O, illustrating and describing their machinery for use about gas plants, for the handling of coal, coke, etc.

The Moechel & Lowther Engineering Company of Kansas City, Mo., have established a consulting office and testing laboratory for chemical engineering and industrial engineering work at 1110 and 1112 Wyandotte Street, Kansas City, Mo.

The Wilson-Maeulen Company have reopened a New York City office and exhibition room at 1 East Forty-second Street where their newest apparatus for the measurement and recording of high temperatures may be seen. Coincident with their return to this city, it is announced that Mr. C. H. Wilson is now the sole owner of the business, having purchased the interest of his former partner, Mr. Frederick Maeulen. The business will continue under the old name of Wilson-Maeulen Co., and their most popular line of low-resistance thermoelec-

tric pyrometers will still be known as the "Advance Electric Pyrometers."

Cyanide Plants.—The Pacific Tank Company, of San Francisco, have sent us their new mining and cyaniding catalog, known as Catalog 7. The company makes a specialty of complete cyanide plants, tanks, mining and mill supplies. The catalog is well gotten up and nicely illustrated and contains many tables and information useful to the cyanide engineer.

The Bureau of Standards in Washington, have just issued a revised edition of their regulations on the testing of glass volumetric apparatus. The attention of chemists should be called to the fact that certain essential changes have been made in the regulations previously published. Copies of the new edition may be obtained free upon application to the bureau.

Seventeen Years of Experimental Research and Development.—On the occasion of the presentation of the Rumford medal to Mr. Edward G. Acheson for his electric furnace products, Mr. Acheson delivered to the American Academy of Arts and Sciences, in Boston, a very interesting review of his electric-furnace work on carborundum, graphite, silicon and siloxicon, and then dealt especially with his researches on colloidal or deflocculated graphite. This lecture has just been issued in form of a very neat illustrated pamphlet.

Solderless Cable Joint.—Messrs. Dossert & Company, 242 West Forty-first Street, New York, have just issued an illustrated pamphlet on the Dossert solderless electrical connectors or cable joints for stranded or solid wire. This mechanical joint should be of special interest for electric-furnace conductors and electrolytic tank connections. This joint is naturally not affected at all by heat. It has the further advantage that when once made, it is absolutely permanent, but that it can be easily disconnected when so desired.

The American Gröndal Kjellin Company of New York City have sent us two well-illustrated pamphlets, one dealing with the Gröndal charcoal kiln, the other with the Gröndal processes of concentration and briquetting iron ores. The charcoal kiln we intend to describe in a future issue. Concerning the concentration and briquetting of iron ores, see the paper by Mr. P. McN. Bennie on page 134 of our Vol. V.

The American Manganese Bronze Company has recently been formed with offices at 99 John Street, New York, and works at Holmesburg, near Philadelphia, Pa. Mr. Charles R. Spare, formerly chemist with Cramps Ship Yards, Philadelphia, is the general manager, and several of the main products of the company will be known by his name, namely, Spare's manganese bronze, Spare's white bronze and Spare's hydraulic bronze. In addition the company will manufacture United States government alloys, and will specialize on marine hydraulic work and high-power machinery.

Aluminium Castings.—Very favorable results have been obtained in service from castings manufactured from aluminium-magnesium alloy. The castings containing 8 to 10 per cent pure magnesium are about 15 per cent lighter than the aluminium-copper alloy and also about 33 per cent stronger. Recent experiments made in the machining of castings made of aluminium and magnesium showed that the castings machined 75 per cent faster than those which are made of the alloy of aluminium and copper. In order to get the best result it is necessary to use the purest grade of magnesium metal. This, another product of electrochemistry, is now on the market. We are obliged to Messrs. C. W. Leavitt & Company, of New York City, for sending us a sample bar of pure magnesium metal.

The American Blower Company of Detroit have issued a new edition of their engine catalog in which they have included a number of new sizes recently placed on the market.

The Moore Filter Company have closed a contract with the San Rafael mine, of Pachuca, Mexico, of which Sr. Edmundo Girault is manager, and Mr. J. B. Empston is consulting engineer, for a type A filter plant of a daily capacity of 250 tons.

It is proposed to double the capacity just as soon as the first unit is in operation.

Cyanide Process.—To all interested in gold metallurgy, the cyanide catalog, just issued by the Colorado Iron Works Company, of Denver, should be welcome, as it contains a concise and well-written outline of the cyanide process, its history and technique, besides fully illustrated descriptions of all kinds of machinery required in cyanide plants. The catalog contains many useful data for the practice, like table of tank capacities on page 93. The catalog bears the earmarks of careful and original preparation.

The Rockwell Furnace Company of New York City, have just issued a well-illustrated pamphlet on their portable heaters for oil fuel. They are intended for heating work which is too bulky or inconvenient to remove to a furnace, and where it is desirable to take the heater to the work, as is the case with annealing, hardening, expanding, bending, brazing, skin drying, lead melting and rivet heating. A descriptive article on this process may be found on page 85 of our February issue.

Messrs. Waller & Renaud, chemical engineers, 159 Front Street, New York City, have sent us a little pamphlet containing an article by H. S. Renaud on coal-pile extravagance, which is well worth the attention of coal buyers. The author quotes W. L. Abbott as follows: "The greatest possibilities for saving or wasting about a steam plant are undoubtedly in the coal pile, but as it is a dirty proposition and many of its features not well understood, the subject does not receive the consideration to which it is entitled." Mr. Renaud urges emphatically to contract for coal on specifications and analysis, and discusses tests on the heating value of different coals in B.t.u., referring also to other considerations which affect the value of coal.

The Goldschmidt Thermit Company of New York City have under construction a new machine shop and foundry. The building occupies a site 34 ft. x 90 ft. in size, just back of their present factory in Jersey City, and is to be fitted up for the purpose of handling to better advantage the extensive repair work which is now being carried on at these works. Traveling cranes will be provided, and no expense will be spared to make the building the most complete thermit repair shop in the country. Special attention will be paid to the rapid execution of the repair of electric-motor cases, truck frames, cast-steel gear wheels, crank shafts, and, in fact, any wrought-iron and steel sections not exceeding 2000 lb. in weight.

The Schutte & Koerting Company of Philadelphia, Pa., manufacturers of steam and engineering specialties for power plant, chemical and other industries, have opened a branch sales office in the Keenan Building, Pittsburg, Pa., where they are represented by Mr. E. A. Knowlton. We also have received their new catalogs, which are being distributed in three sections; one section pertaining to apparatus for the chemical industry; one to apparatus for use in power plants, etc., and a general catalog illustrative and descriptive of their entire line of products, which is probably one of the most up-to-date and complete catalogs published by any engineering firm. These catalogs will be sent on request to those interested.

Nitrating Centrifugal.—We have received from Mr. J. W. Sittig, 5 Beekman Street, New York City, a descriptive circular of the nitrating centrifugal of Selwig & Lange, of Brunswick, Germany, whom Mr. Sittig represents in this country. While the Selwig & Lange nitrating centrifugal has stood the test of thirteen years' experience on a commercial scale in a very satisfactory manner, it has recently been considerably improved in various details, especially in the contrivance for circulating the acid during nitration, in the provision of a detachable steel acid receptacle, and in the Wolfshohl arrangement for the automatic immersing of the material to be nitrated. This centrifugal, in combination with the hydraulic gun-cotton conveyor, is used in numerous gun-cotton, explosive, celluloid and artificial silk factories and in many chemical plants. Nine such

centrifugals are in use in the Marine Powder Factory of the Navy Department of this country. In the circular sent to us the main principles of the apparatus and the features of recent improvements of the same are described and illustrated.

Metallic Manganese.—We have received from Messrs. C. E. Leavitt & Co., of New York City, a sample bar of metallic manganese, analyzing over 99 per cent pure. This metal has a specific gravity of 7.4, and is used to a considerable extent as a deoxidizer in brass foundry work, and also, to a limited extent, as a deoxidizer in making steel castings, being a substitute for aluminium. Tables recently published give the atomic weight of magnesium as 23.04, the atomic volume as 13.8, and the melting point as 649°.

Production and Consumption of Spelter.—According to an advance statement of the United States Geological Survey the production of spelter in the United States in 1907 was 249,860 tons (of 2,000 lb.), against 224,770 in 1906, the increase being 25,090 tons or 11.2 per cent. The consumption of spelter in the United States in 1907 was 228,509 tons, against 221,781 in 1906; the increase being 6,728 tons or 3.0 per cent. The production of spelter in the world in 1907 was 813,843 tons, against 775,871 tons in 1906, the increase being 37,971 tons or 4.9 per cent. This shows that almost exactly two-thirds of the total increase in spelter production in the world was obtained in this country.

Nitric Acid from Air.—The *Elektrotechnische Zeitschrift* states that Messrs. Sager and Woerner, in Munich, have applied for the right to erect a large nitric acid plant in Kardaun, near Bozen, in southern Tyrol. Water power is to be used and the power plant is to be equipped with six turbines each of 8,500 h.p. There is already a plant in Tyrol making nitric acid from air. It is located near Innsbruck and is furnished with energy from the Sill works. Nothing is stated concerning the process to be used in the new plant.

Digest of Electrochemical U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

ELECTRIC FURNACES (Continued).

531,143, December 18, 1894, J. W. Woodfolk and J. C. Wharton, Nashville, Tenn.

Arc type. Springs an arc from a stream of acidified water to an electrode which may be a bar of iron to be heated or a tube containing a charge of ore to be smelted. Shows three furnaces: In the first, the arc is sprung from an annular sheet or film of water, flowing down the inside of a tubular positive electrode lined with lead, to a concentric bar of metal to be heated or melted, constituting the negative electrode. The sheet of water may be maintained in position by centrifugal force. The second furnace has a hollow globular body, serving as anode. A sheet of acidulated water flows down its inner surface, from an upper reservoir to a lower receptacle, being returned by a pump and pipe. The arc is sprung from the water to a tubular central cathode, containing, e. g., ore, fuel and flux. The resulting metal and slag collect in a lower crucible or separator, from which they are separately tapped. The electrolytic hydrogen from the water assists in reducing the ore, or may be burned by injected air. The third furnace is similar to the second, but the hollow anode has an oxidizable lining of carbon, lead or iron to combine with the electrolytic oxygen. Finely-divided oxidizable material may also be diffused through the stream of water. The tubular cathode has a cover which is connected to an exhaust fan by a valved pipe. The valve may be closed, to confine the vapors, which are then condensed by the water; or it may be opened and the vapors exhausted, and combustible gases and air drawn or forced through the charge, as a flame.

537,005, April 9, 1895, G. D. Burton, Boston, Mass.

Arc type. The arc is sprung from a stream of water containing dissolved chemicals, to lumps of ore to be smelted. The solution, which may consist of water, eight quarts, sodium carbonate, twelve pounds, and borax, one pound; or of water and equal parts of cream of tartar and sodium chloride, is dipped up from a receptacle by a conductive bucket-wheel, serving as anode, and poured upon the upper end of an inclined railway of lead, from which it runs onto an inclined hearth of wood covered with firebrick. Midway the hearth is a transverse metal plate serving as cathode and receiving the lumps of ore. This plate may be of lead, copper or iron. The stream of solution running from the lower end of the hearth is broken by a screen and deflector. The ore to be smelted may be a sulphite carrying gold, silver, lead and arsenic. A current of from one to three hundred amperes, at five to ten hundred volts, may be used. The ore may be fluxed and the lead, silver and gold successively smelted out, after burning off the sulphur and arsenic. The fused metal runs off the hearth and collects in the solution-reservoir in globules. The electrolytic hydrogen from the solution burns and assists in heating, a flame appearing over the cathode. Aluminium may also be smelted out of clay.

537,009, April 9, 1895, G. D. Burton and E. E. Angell, of Boston and Somerville, Mass.

Resistance type. Closed forge for heating metal bars or ingots. The bars are placed through holes in one horizontal copper bar electrode into aligned sockets in a parallel electrode, and constitute resistors. The forge has a bottom and sides of asbestos-board, and a dome top of mica or glass. The electric mains are cooled by an air current, extending transversely through a pipe leading from a blower. The forge may have a brick hearth. A modified forge consists of a tube of metal or a transparent non-conductor, having end electrodes to receive a single bar.

538,271, April 30, 1895, H. G. O'Neill, Boston, Mass.

Resistance type. A covered crucible to be heated is imbedded in a resistor of lumpblack mixed with diatomaceous earth, which is contained in a vessel molded from a mixture of diatomaceous earth and kaolin or fireclay, or from asbestos. This vessel has two vertical opposite recesses in its sides, receiving carbon bar electrodes. It is also wound with a resistance wire, having sections connected to switch-points. The current passes in series through the wire and resistor. The heat generated may vaporize carbon.

The reduction of the most refractory ores may be effected in a small way by twelve hundred watts.

550,866, December 3, 1895, F. Chaplet, Laval, France.

Arc type. Substances to be melted are placed in an inclined retort-tube, e. g. of carbon, which is heated by one or more external arcs; or they may be placed in small crucibles introduced into the retort-tube. The tube may extend transversely through a heating chamber, being closed at its ends by stoppers, or it may terminate at its lower end within the furnace, and may have a top hole for delivering the melted substance into a lower receptacle. Two tubes may incline downward and meet within the furnace. The carbonarcing electrodes may be supported on wheeled carriages. An arc may be sprung near the tap-hole.

The furnace chamber receiving the retort tube or tubes has a concave roof and hearth, to reflect the heat from the arcs onto the tube.

551,014, December 10, 1895, J. A. Vincent, Philadelphia, Pa.

Arc type. The ore or pulverized charge is fed from a hopper-mouth through a horizontal passage between superposed carbon-block electrodes, by a screw. The upper electrode is automatically adjusted. The solid products fall into a pit and the gases escape to a stack. Suitable for production of calcium carbide.

NEW BOOKS.

THE METALLURGY OF IRON. (Being one of a series of treatises on metallurgy; written by associates of the Royal School of Mines; ed. by Sir W. Roberts-Austen.) By T. Turner. 478 pages, illustrated. Bound in cloth. Price, \$1.25. Philadelphia: J. B. Lippincott & Co.

AUTOGENOUS WELDING OF METALS. Translated from reports of the National School of Arts and Trades of France. By L. Leon Bernier. 45 pages, illustrated. Bound in cloth. Price, \$1. New York: Boiler Maker.

THE ENERGY CHART FOR RECIPROCATING STEAM ENGINES. By Captain H. R. Sankey. 170 pages, illustrated. Bound in cloth. Price, \$3. New York: Spon & Chamberlain.

LEATHER INDUSTRIES LABORATORY BOOK OF ANALYTICAL AND EXPERIMENTAL METHODS. By H. Richardson Procter. Second edition, revised and enlarged. 475 pages, illustrated. Bound in cloth, price, \$7.50. New York: Spon & Chamberlain.

THE ART OF PAPER-MAKING. By Alexander Watt. (A practical handbook of the manufacture of paper from rags, esparto, straw and other fibrous materials, including the manufacture of pulp from wood fiber, with a description of the machinery and appliances used, to which are added details of processes for recovering soda from waste liquors.) Third edition. 272 pages, illustrated. Bound in cloth. Price, \$3. New York: D. Van Nostrand Co.

THE DISTRIBUTION OF GAS. By Walter Hole. 703 pages, illustrated. Bound in cloth. Price, \$5 net. New York: Spon & Chamberlain.

PRACTICAL INDUCTION COIL CONSTRUCTION. By J. Pike. 128 pages, illustrated. Price, 50 cents. New York: Spon & Chamberlain.

ENGINEER'S POCKET DICTIONARY OF TECHNICAL TERMS. By M. Loeff. French-English. 80 pages. Bound in cloth. Price, 60 cents. New York: Spon & Chamberlain.

A GUIDE TO TECHNICAL WRITING. By T. A. Rickard. 127 pages. Bound in cloth. Price, \$1 net.

BOOK REVIEWS.

THE DATA OF GEOCHEMISTRY. By Frank Wigglesworth Clarke. (United States Geological Survey. Bulletin No. 330, Series E, Chemistry and Physics, 54.) 716 pages. Washington: Government Printing Office.

This handsome volume, issued by the U. S. Geological Survey, is a treatise of broadest interest.

"Upon the subject of geochemistry a vast literature exists, but it is widely scattered and portions of it are difficult of access. The general treatises, like the classical works of Bischof and of Roth, are not recent, and great masses of modern data are as yet uncorrelated. The American material alone is singularly rich, but most of it has been accumulated since Roth's treatise was published. The science of chemistry, moreover, has undergone great changes during the last twenty-five years, and many subjects now appear under new and generally unfamiliar aspects. To bring some of the data together, to formulate a few of the problems, and to present certain general conclusions in their modern form are the purposes of this memoir. It is not an exhaustive monograph upon geochemistry, but rather a critical summary of what is now known and a guide to the more important literature of the subject. If it does no more than to make existing data available to the reader, its preparation will be justified."

There are 27 chapters, dealing with the chemical elements, the atmosphere, lakes and rivers, the ocean, the waters of closed basins, mineral wells and springs, saline residues, volcanic gases and sublimates, the molten magna, rock-forming minerals, igneous rocks, the decomposition of rocks, sedimentary and detrital rocks, metamorphic rocks, metallic ores, the natural hydrocarbons, and coal.

Prof. Clarke's work should prove of great interest to chem-

ists, mining engineers, metallurgists, and geologists alike. The careful and critical summary of what has been done in geochemistry in the past is of practical value just now when a noteworthy beginning is being made to apply the principles and methods of modern physical chemistry to the big problems of "worlds in the making." To anybody interested in these problems, Prof. Clarke's work will be a valuable help in showing what has been done in the past. The references to existing literature are very full. There is a good index of 48 pages.

* * *

INDUSTRIE DES METAUX SECONDAIRES ET DES TERRES RARES. By Paul Nicolardot. 448 pages, 37 illustrations. Bound in cloth. Price, 5 francs. (Retail price in New York, \$1.25.) Paris, France: Octave Doin.

This is a book that exposit a new and growing field of metallurgical endeavor. As is well known, metals and earths that were only of scientific value 10 years or so ago have by their special qualities been found of value in our modern complex industrial world. We need only mention cerium, thorium and zirconium, whose oxides are the base of the incandescent mantle and the Nernst lamp, tungsten, molybdenum, which have proved of so much value in special steels, and tantalum, as well as tungsten, which are used in new high-efficiency electric filament lamps so startling to the central station manager.

Paul Nicolardot, captain of the French Artillery, has done a useful work in giving this compilation of what is known about these expanding industrial products. Their deposits, geology, chemistry, metallurgy and uses are given with a commendable fulness in detail. While the investigator of such subjects will be forced to get most of this information first-hand, nevertheless this book is a useful finger-post to show the way.

* * *

THE ELECTRIC FURNACE: Its Evolution, Theory and Practice. By Alfred Stansfield, D. Sc., Associate of the Royal School of Mines, Professor of Metallurgy in McGill University. 211 pages, 53 illustrations. Price, \$2. Toronto: The Canadian Engineer; New York: Hill Publishing Co.

Dr. Stansfield's book is undoubtedly the best book now available on the electric furnace and its application in the metallurgical industries. Moissan's classical work deals with the electric furnace as a laboratory apparatus and is restricted to the limited field of applications in which Moissan himself was particularly interested. It is significant that in Moissan's work the name of Héroult is not once mentioned. Wright's more recent book is of a popular character and gives descriptions of all sorts of laboratory and industrial furnace designs, practical and impractical, indiscriminately thrown together.

It is in comparison with Wright's book that Dr. Stansfield's new treatise appears to best advantage, being a concise and able summary of the most reliable data available on electric furnace construction, with descriptions of the most important electric furnace processes. The compilation of the many data has been made with sound metallurgical judgment. The full references to original papers and articles are most valuable.

The title of Dr. Stansfield's book seems to be too broad and not fully justified by the contents. Yet it is the best book now available on the electric furnace in its broadest industrial aspects and we must be grateful to the author for having written it.

There are seven chapters: History of the electric furnace; description and classification of electric furnaces; efficiency of electric and other furnaces, and relative cost of electrical and fuel heat; electric furnace design, construction and operation (containing data on refractories for furnace lining, materials for resistors, etc.); production of iron and steel in the electric furnace (production of steel from scrap, pig iron and iron ore; production of pig iron from iron ore, carbon and fluxes; direct production of steel from iron ore); other uses of the electric furnace (ferro-alloys; graphite and carbides: zinc, silicon, quartz, alundum, nitric acid, phosphorus, carbon bisulphide, aluminium and sodium); future developments of the electric furnace. The book is concluded by a good index of 17 pages.

Electrochemical and Metallurgical Industry

VOL. VI.

NEW YORK, OCTOBER, 1908

No. 10.

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH. D.....President
E. F. ROEBER, PH. D.....Editor and Secretary
C. E. WHITTLESEY.....Treasurer

*Yearly subscription price for United States, Mexico and
United States dependencies, \$2.00; for all other countries, \$2.50
(European exchange, 10 shillings, 10 marks, 12.50 francs).*

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Entered as Second-Class Matter, June, 1903, at the Post Office at New
York, N. Y., under the Act of Congress, March 3, 1879

NEW YORK, OCTOBER, 1908.

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Men and Not Dollars

It is too often true that engineers become so absorbed in the commercial and practical problems of their profession that they do not give any thought to its higher and altruistic aspect. This we believe is due to the general and widespread mistaken view of life, confined to no one class of men in our country. Too manifest is the rampant spirit of crass materialism and the unhealthy desire to make the finest pile of fagots in the form of "the roots of all evil." To live simply for one's self is a form of selfishness that will burn itself out in time. On the other hand, every man of decent character wants a competency to make himself and his family live in a proper manner.

* * *

But, as in all things in this complex and funny world of ours, we should strive for the balanced mean. The ancient Roman philosopher who said that "in the middle of the road was there the safest passage" uttered a truth that again and again has re-echoed in the councils of the sages. We should balance things as we find them with things as they should be and strive to mix the real with the ideal in a common-sense and plain sort of way. So, then the engineer ought to produce commercial results; this, we believe, is his function. But at the same time he should hold to the doctrine that money is a power that must be controlled as any other material power. A water-power producing electric power in an honestly built plant is a fine sight. A water power that sweeps away a dam built by a grafter or an ignoramus is a sight that connotes the thought of the devil, for it embodies an element of evil and disgraces a noble profession. As Lord Francis Bacon says, "I hold every man a debtor to his profession, from the which as men, of course, do seek contenance and profit, so ought they of duty endeavor to be a help and ornament thereto."

* * *

A notable example of professional altruism is evidenced by the withdrawal from the metallurgical staff of one of our large metal companies of an engineer at a period of maximum financial productivity and the assumption by him of a professional position in one of our technical schools. This man has been one of the factors in developing our modern metallurgical processes, not by especial brilliancy, but rather by his well-ordered mind and his practical adaptability. He now has a chance to show his ability to produce engineers rather than metals, and men rather than dollars. That he has the sanity to take this step is, we believe, a proof of his ability to inculcate correct principles of his profession in our sons. We may be a bit old-fashioned, but we believe men are a rather finer and more satisfying product than dollars. This engineer will give more than receive, but in giving will he become richer. For he pays his debt to society and no man can be rich until his debts are paid.

The British Chemical Industry.

The most important clause of the new British patents act, on which we commented in our March issue, requires that the article or process which is protected by patent must be manufactured or carried on to an adequate extent in the United Kingdom after the expiration of four years from the date of the patent. It has been estimated that in the immediate future a sum of at least \$125,000,000 of foreign capital will have been invested in Great Britain in order to comply with the new law. The establishment of branches of two of the largest German chemical works at Ellesmere Port and at Port Sunlight is already reported. Thus the coal tar industry returns to the country of its birth. But will the new patents act really result in an uplift of the British chemical industry? Prof. F. S. Kipping, in his recent Dublin address to the chemical section of the British Association, answers this question in the negative. "If, in this free-trade kingdom production is cheaper than abroad, the foreign firms which have branches here will be in a position superior to that which they now occupy in their own countries. If, on the other hand, owing to inefficient labor, higher wages, freight and other economic conditions, production is more costly, the superior efficiency and scientific organization of these foreign firms will, nevertheless, enable them to command our home market with the goods made here, and to cut us out in the world market, as they do now with those made abroad." . . . "Although the new patent act will prove to be of great value in many respects, it will do little to foster British chemical trade and the development of British chemistry." . . . "The shadow of the cypress rests upon our chemical trade, and manufacturers do not see their way to employ chemists."

* * *

It is probable that Dr. Kipping is unduly pessimistic. But his able discussion of possible remedies for what is wrong in the interrelation between chemical industry, chemical science, and chemical education, deserves full attention. He emphasizes chiefly the necessity of training the future works chemist in methods of research. He warns us not to imagine that when a chemist thus trained enters the works he should or could immediately become an engineer and a commercial expert. The practical man—that is to say, the man who has a thorough and useful knowledge of some particular manufacturing process—must be trained under practical men in the works, and we must not imagine that a course of evening classes will convert him into an expert chemist. The ideal man who combines high scientific training and sound practical knowledge cannot be produced unless the period of his education is extended to half a lifetime.

* * *

The difficulty sketched by Dr. Kipping is not unknown in this country, nor does it apply solely to the chemical industry. Dr. Kipping looks for remedies by comparing British and German methods. It seems equally suggestive to compare the methods of the chemical and electrical industries. The latter have formerly experienced similar troubles. The most significant and revolutionary change in the organization of our large electrical manufacturing companies is the fact that their sales departments are now recruited from the engineering staff. The salesman is a technical graduate; in these days of eager business competition he must have all the technical knowledge on the

spot. The large electric lighting stations follow the same policy. There are 50 technical graduates on the staff in Denver, and another station recently engaged 20 technical graduates at one time. But we cannot send analytical chemists on the road, says the chemical manufacturer. Of course, not. What the electrical industry does, is to get the best raw material from the universities and technical institutions—graduates who have learned the principles and master them thoroughly. And this raw material is developed into engineers in the works in the course of time; and when any department whatever of the organization needs a good man they are sure to find him. Mr. Carnegie's wonderful success was due to a large extent to putting his best practical steel men on the head of the business departments. What Mr. Carnegie does now in furthering education is in line with the same policy. In the chemical and metallurgical industries (as in others) great importance has been laid in the past on making shrewd business contracts, on controlling raw materials, etc. This is all very proper. But in future more will be needed. Sound business judgment must be based on and amalgamated with sound engineering judgment and the future leaders of the chemical and metallurgical industries will and must be the engineering students of to-day.

The Future of Iron and Steel Demand.

It is useless to deny the statement, when so well attested by the experience of many years, that there is a rhythm in the movements of business activity. In the iron and steel trade particularly startling coincidences are observable, hardly without discrepancies. One might suppose, at first thought, that the iron and steel industry would be less likely than other lines of business to yield to influences of a cyclical nature, on account of its rapid growth, since for many years production has been doubling on an average every nine or ten years. It does yield, however, and it may be that it is this very rapid growth which makes the industry particularly susceptible to such influences. The entire cycle involves a period of something like 20 years, as is clearly attested by many phenomena. Why the time should be 20 rather than some other number of years, efforts have been made to explain. The time has been coupled with the supposed life of a business generation, with the solar sunspot period, as possibly measuring a meteorological period with its effect upon crops, with the presidential term, of which it is a multiple, and so on. Since a more general recognition that business has been moving in cyclical form would lead business men to anticipate the movements and prepare for and, therefore, forestall the unfavorable ones, it is more important to recognize than to explain the phenomena. One important reason why the rhythmic movement is not generally recognized as a means of forecasting the future is the popular superstition that this is altogether a new era, subject to new influences and witnessing new departures.

* * *

Much has been said lately of the necessity of the railroads for strengthening permanent way on account of heavier trains, and the general necessity of substituting steel for wood. In discussing briefly the condition of the iron trade in 1887 and the early part of 1888, the even 20 years ago, Mr. James M. Swank, in the annual statistical report for 1887, said: "The increased weight of trains in late years has called for stronger iron and steel bridges, and many of these were substituted for lighter

bridges in 1886 and 1887. The modern tendency to substitute iron and steel structural shapes for wood in the erection of public and private buildings was everywhere very noticeable in 1886 and 1887." Railroad building and development has shown three distinct rates of movement in the 20-year period. The annual statistics of cars, locomotives and miles of railroad built invite this division so clearly that it seems unnecessary to give them in detail here. Using Poor's statistics, which in general refer to fiscal years, ending the middle of the calendar year of similar designation, the periods are the nine years from 1879 to 1887, inclusive, the six years 1888 to 1893, the five years 1894 to 1898, and then again the nine years 1899 to 1907. The number of locomotives, cars and miles of railroad in existence at the ends of these years has been as follows (the figures for locomotives and cars in 1889 being substituted for those of 1878, as no statistical figures for the latter year were available):

	Locomotives.	Cars.	Miles of road.
1878.....	17,949	556,930	81,747
1887.....	27,275	976,772	149,214
1893.....	36,118	1,241,500	177,516
1898.....	36,746	1,318,700	186,810
1907.....	58,301	2,131,487	228,128

The average annual increase in the periods has been as follows:

(Inclusive)	Locomotives.	Cars.	Miles of road.
1879 to 1887, 9 years.....	1,331	59,977	7,496
1888 to 1893, 6 years.....	1,474	44,121	4,717
1894 to 1898, 5 years.....	126	15,440	1,859
1899 to 1907, 9 years.....	2,395	90,310	4,591

While the annual statistics indicate most clearly that the above are the years which should be selected to mark the termini of the periods, it is well remembered that changes in general conditions occurred just at the times indicated. Remembering that fiscal years are designated, in the case of locomotives and cars, and calendar years in the case of miles of railroad, the bank crash of 1893 occurred in June, or just at the close of the fiscal year 1893; the foundation of the 1899 boom was laid in the fall of 1898 by heavy rail purchases, just a few months after the close of the fiscal year 1898, and the present depression was first seriously felt last October, three months after the fiscal year 1907 ended.

* * *

The above table showed that in the six-year period 1888 to 1893, inclusive, there was less railroad activity than in the nine-year period preceding, there being a moderate falling off in the increase in number of cars and of miles of railroad, but with a slightly larger increase in locomotives. In the five-year period following there was a heavy decrease in all three items. In the next nine-year period there was a duplication of the extreme activity of the nine-year period of 20 years earlier, but it was more in the direction of cars and locomotives and less in the direction of new line built. That is a natural variation. The statistics of mileage refer to miles of railroad, irrespective of track, and in the later period there was much double tracking, which does not appear, but naturally involved a great increase in rolling stock. These three classes of statistics each have their bearing. The facilities are interdependent. It would be convenient to reduce the figures to a common denominator and add them. This reduction can be accomplished by a method which at first glance may appear a trifle weird, but which, on reflection,

has much to commend it. The total increase in locomotives in the entire period under review is just about one-thirtieth, in point of numbers, of the increase in cars, while the increase in number of miles of road is just about one-fourth the increase in number of cars. If, then, we multiply the number of locomotives by 30, and the number of miles of road by four, we shall be given about equal weight to each of our three classes of statistics, and adding the numbers together we have the following index numbers to railroad expansion and improvement in the periods:

Annual average.	Index number.
1879-1887.....	129,921
1888-1893.....	107,209
1894-1898.....	26,656
1899-1907.....	180,424

* * *

The impression has remained that 1887 or 1888 ended the period of heavy railroad building, and such was the case, as relates merely to the miles of new railroad built. In 1887 there was an increase of 12,876 miles of railroad; in the next year the increase was 6900 miles, while in no subsequent year has the increase reached 5500 miles. There was not a cessation of railroad activity, but following 1887 there was a diversion of the money to a different class of improvements. Just now there is an impression in some quarters that last year has probably marked the end of heavy railroad expenditure for some years to come. There have been, it is true, very heavy increases in rolling stock, and not a great deal of expansion in that direction is probable. In the direction of new and heavier bridges, heavy rails to replace light or worn-out rails, improvements to terminals, and in other ways, there is left a great deal of expenditure to be made by the railroads. There will necessarily be some change in the direction of the expenditure, but quite likely the decrease in the total sum may not be greater than the slight decrease from the period 1879-1887 to the period 1888-1893. The question of the ability of the railroads to expend large sums of money on improvements has been taken out of its bearing, to an extent, by the propaganda which have been circulated to disarm sentiment against an advance in freight rates. Of late the movement has assumed the form of an organized campaign. Claims are made that the rate of revenue is insufficient to permit the making of absolutely necessary repairs and improvements. As a matter of fact, the railroads have introduced many economies, the effect of which cannot be observed both from the lateness of their introduction and from the fact that the amount of business being done by the railroads in the carriage of freight and passengers is abnormally low.

* * *

If it be admitted that the iron and steel trade is under cyclical control, the evidence for prosperity in the next few years is excellent. Despite the moderate reduction in railroad expenditures in the period 1888-1893, the iron and steel trade was quite prosperous. There was a setback in 1888, similar in its nature to the one being experienced at present, but in the following four years there was a steady and satisfactory flow of business. The increased capacity was engaged, the railroads taking less and other consumers more, than in the previous period. All present indications point to a repetition of that experience.

New York Meeting of American Electrochemical Society.

The annual meeting of the American Electrochemical Society will be held in New York City on Oct. 30 and 31. The preliminary program has been arranged as follows:

Headquarters for registration and information will be at the Hotel Cumberland, Fifty-fourth Street and Broadway. This was also the hotel headquarters last year. On Thursday, Oct. 29, a meeting of the board of directors will be held at the Chemists' Club in the evening.

The general meeting will begin on Friday, Oct. 30, at 9 a. m., with a session devoted to reading and discussion of papers at the Doremus Lecture Theater, Chemistry Building of the College of the City of New York. At 12:30 a luncheon will be tendered to the society by the staff of the department of chemistry, College of the City of New York, Alumni Hall, Main Building. This will be followed by another session for the reading and discussion of papers beginning at 2 p. m.

In the evening an informal subscription dinner will be held.

On Saturday, Oct. 31, a session for the reading and discussion of papers will be held at the Chemists' Club beginning at 9 a. m. Lunch will be taken at 1 o'clock at the Hotel Cumberland and an excursion will be made in the afternoon.

The meeting will be closed by a smoker of the Chemists' Club in the evening.

Details of the program will be published in our next issue, which will be mailed four days in advance of the meeting.

Production and Prices of Non-Ferrous Metals.

The *Metallgesellschaft* and the *Metallurgische Gesellschaft A. G.*, of Frankfurt-on-Main, have just issued the 14th annual volume of their Comparative Statistics of Lead, Copper, Spelter, Tin, Aluminium, Nickel, Quicksilver and Silver.

The great care with which these annual statistics are prepared and their authoritative character are well known.

In the introduction it is pointed out that the year 1907 will figure in the history of metals as the year of extremes, so wide a range between the highest and lowest daily prices having scarcely ever before been known during the last 30 years. The range of price variation (i. e., the difference between the highest and lowest prices in 1907) was

For lead	£9.10	or 42.2 per cent
" copper	57.10	" 51.3 " "
" spelter	8.17/6	" 31.5 " "
" tin	8.5	" 42.5 " "

The percentage figures represent the range of price variation in per cents of the highest price in 1907.

"It would be idle to attempt, upon the lowest prices of the above-named metals during the last 30 years, to base conclusions as to the future, seeing that, on the one hand, these lowest prices in every case ruled only for a brief period, and that, on the other hand, the conditions both of production and of consumption of these metals have undergone important changes. Worthy of special mention is the fact that the cost of production in most of the chief mining districts has risen very considerably, in consequence not only of the advance in wages and price of materials, but also, in part of the deposits becoming poorer, more difficult mining conditions, etc., so that many mines have already reached the limits of profitable production.

"The necessity of adapting oneself to the altered conditions of things, due to the lower level of metal prices, should doubtless bring about a reduction of the cost of production below the level prevailing during the boom, but it must be observed that in many mining districts the low costs formerly ruling can never again be attained.

"So sharp and swift a fall on the metal market must naturally exert much more unfavorable effects upon the mining industry

than more gradual declines, as these latter more readily permit of owners accommodating themselves to the altered circumstances by means of a gradual reduction of cost, effected through economies and improvements.

"The same thing is, of course, equally true of smelting works. Those which commenced operations during the period of great prosperity and were only gradually able to develop their production, must also be seriously affected by the falling prices. Similarly with those smelting and rolling works whose regular working stock—as not infrequently happens—had been taken into the accounts at the prices ruling when the books were made up, and hence, during the prosperous times, had been valued at a higher rate year by year; the fictitious earnings thus shown disappears, of course, now, when the lower prices have to be reinstated.

"The unfavorable position of the metal market during the past year was reflected, during its closing months, in the state of consumption, and also in that of production, especially in the United States. The world's production of spelter alone shows a notable increase, which, however, is both absolutely and rela-

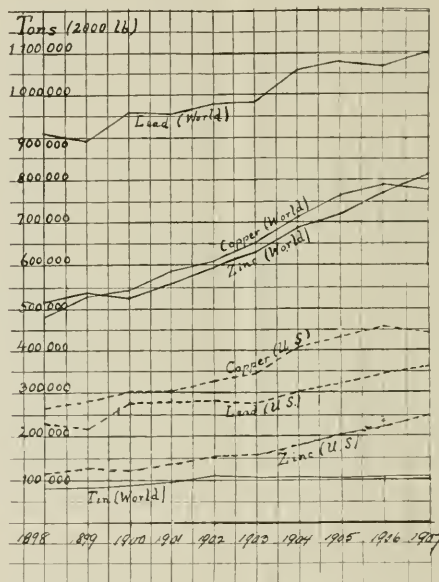


FIG. 1.—PRODUCTION OF METALS.

tively inferior to that of the preceding year, while the total production of lead, copper and tin underwent no change of importance."

After these introductory notes, general summaries are given of the lead, copper, spelter and tin industries, followed by a comparative statement of the Anaconda Copper Co's balance sheets and the eighth annual report of the American Smelting and Refining Co.

The bulk of the volume is taken up by comparative statements (in form of statistical tables) on the production and consumption and prices (also exports and imports) of lead, copper, spelter, tin, aluminium, nickel, quicksilver, and silver.

From the enormous amount of statistical information, contained in these pages, it seemed worth while to collect a few of the most important figures and present them to our readers in form of curve sheets. This is done in the adjoining Figs. 1 and 2. These curves supplement those given on page 40 of our

issue of January last, in which the price fluctuation of the different metals during 1907 was shown.

In the adjoining Fig. 1 the fluctuation of the yearly production of metals in the last 10 years for 1898 to 1907 is shown. The drawn-out curves represent production in the world, the dotted curves production in the United States. The figures

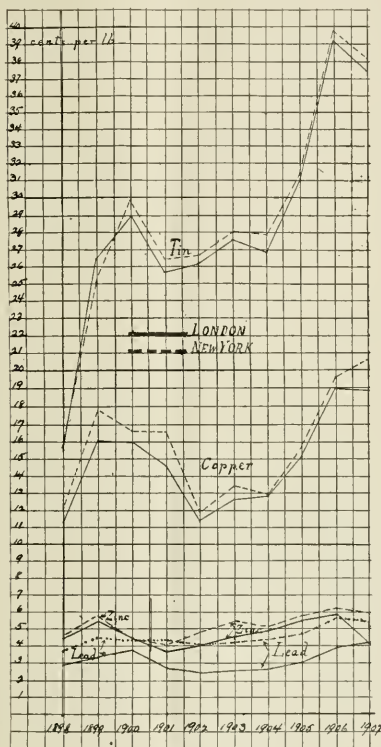


FIG. 2.—PRICES OF METALS.

represent short tons (of 2000 lb.). These curves are plotted from the figures on pages XV, XII, XVIII, XX and 5, 4, 2, and 12 of the Statistics of the Metallgesellschaft.

Fig. 2 shows the fluctuation of the prices of metals in the last 10 years for 1898 to 1907. A mean price is inserted for each year. The drawn-out curves represent London prices, the dotted curves New York prices. These curves are based on pages 97 (standard copper, London), 96 (Lake copper in New York), 92, 94, 106, 107, 108 (foreign tin in London and comparative prices in New York and London), of the Statistics of the Metallgesellschaft.

We trust that both curve sheets will prove interesting. We are obliged to Dr. Franz Meyer, treasurer of the Metallurgical Company of America, for placing the statistics of the Metallgesellschaft at our disposal, and to Mr. H. M. Burkey, engineer of the Metallurgical Company of America, for having compiled and drawn the curves of Figs. 1 and 2.

The Iron and Steel Market.

Purchases of steel products continue to be confined to material required for prompt delivery, so that market activity and production continue to run quite closely together. There has been no more activity in September than there was in July and

August. Producers have not gained anything, but, on the other hand, it is insisted that they have not lost anything, in the month.

The hope has been renounced that there will be any material improvement before the election, if, indeed, there is any before the beginning of the new year. In the spring the "conservative optimism" so much referred to looked for a steady improvement through the year, to an arithmetical increase which would bring the steel industry to a point not far from full operation by the close of the year. Toward the end of May the market became more dull, and remained so during June. In July there was an improvement, and fresh predictions were at once made that there would be a progressive improvement through the year. These expectations also have failed.

The position at this time seems to be that certain light lines, particularly wire products, sheets, merchant pipe and merchant steel bars, have undergone a fairly steady improvement since about June, with prospect of nothing more than a moderate further improvement in the next two or three months, while certain heavy lines, including rails, shapes and plates, have been holding their own since June, but with the prospect of tapering off as the season advances. It is the change which occurs every year at this time, as in years when production is quite uniform through the year there is this change in the distribution of the material. Too much stress has been laid upon the improvement noted in these light lines in the past two or three months; it is a normal thing, and does not ordinarily presage an improvement in total tonnage.

Indeed, it is far from certain that the activity of August and September will be fully maintained through the year. The rate of pig iron production in these months has been about 16,000,000 tons annually, against an average of a trifle under 14,000,000 tons during the first half. There are suspicions that some of the merchant pig iron production has been going into stock, and that some stocks of finished steel products have been accumulated by mills.

The trade at large does not seem to anticipate any quick return in the direction of full activity at the first of the year. Indeed, the predictions are rather less hopeful than one would be led to expect considering the predictions which were freely made earlier in the year, which predictions did not seem to be in line with the tendencies and have not been borne out by events. There is much more reason to expect a return to moderately full activity within six months now than there was to entertain such an expectation six or nine months ago. The year 1908 was marked to be an off year, in characters quite easily decipherable, and it now seems equally clear that 1909 is marked for a year of moderately full activity. While the consumption of iron and steel in this off year is fully equal to the consumption in the boom year, 1899, conditions as to consumption have changed radically and it does not seem possible that the country can long continue at the reduced rate when it is considered that finance and business have really been put upon a pretty sound basis and the crops are distinctly favorable. The lethargy in the iron and steel trade may not disappear as suddenly as activity disappeared late last year, but the disappearance is likely to be more sudden than seems now to be expected.

Pig Iron.

Pig iron has been very quiet in all districts. On the whole, September has probably been the dulllest month of the year. This is accounted for chiefly by the fact that there was a little forward buying in July and August. It did not appear to be heavy, at the time, but now it seems that it was heavy enough. Consumption is probably at as good a rate as it was earlier in the year. New England consumers were shrewd buyers in the summer, the lake front and eastern Pennsylvania furnaces pitting themselves against each other in that territory. As a result of business thus booked, with some local buying, the eastern furnaces have advanced prices about 25 cents, to \$16.75, deliv-

ered Philadelphia, for No. 2 X foundry. During the month Chicago district furnaces reduced their asking prices 50 cents, to \$16.50, delivered Chicago, finally recognizing the competition of Ohio furnaces which were underselling them in their own territory. In the valleys, Bessemer and basic have yielded about 25 cents a ton, to \$15 for Bessemer and \$14.50 for basic, while No. 2 foundry remains, nominally at least, \$14.50. The Southern furnaces remain pretty firm at \$12.50, Birmingham, but a little re-sale iron is offered at concessions.

Billets and Sheet Bars.

The billet market has continued extremely quiet. Although the spread between pig iron and billets is now almost \$10, the billet price of \$25, Pittsburgh, seems to be quite well maintained. It is believed that shading has been indulged in occasionally, but the details of such transactions are carefully guarded. The sheet bar price is very well maintained, and it is understood that an order for 10,000 tons was offered, at a concession of a dollar from the official price, without finding a taker. The regular basis is \$27, Pittsburgh. The movement from the mills is hardly as heavy as it was, since the tin-plate industry is running at a greatly reduced rate, the sheet industry improving slightly.

Finished Materials.

No rail business of any consequence has been placed and at this late date there is no prospect of any buying for this year's delivery. The production of rails in the past few months has been at between 25 and 35 per cent of full capacity, and is likely to decrease. Plates and shapes show no change from July or August. Steel bar specifications in September have been at the better rate shown in August, but there has been no further improvement since then. Demand for wire products has improved, and it is claimed the mills are running at 75 per cent or more of their full capacity. Between 60 and 65 per cent of the sheet mills have been in operation in September, demand showing a slight improvement, particularly for galvanized. Some of the Pacific Coast jobbers have placed some orders for stock. The tin plate season is over. About one-half the leading interest's tin mills ran during September, a somewhat larger proportion of the independents operating. Prices remain as follows, f.o.b. Pittsburgh, except where otherwise specified.

Standard rails, 50-lb. and heavier, \$28, f.o.b. northern mill.
Light rails, 25 lb. to 45 lb., \$23 to \$24.
Plates, tank quality, 1.60 cents.
Shapes, 1.60 cents for beams and channels, 15-in. and under, angles and zeeks; tees, 1.65 cents; large beams and channels, 1.70 cents.

Steel bars, 1.40 cents, base, half extras.
Iron bars, 1.40 cents, delivered Pittsburgh; 1.32 to 1.35 cents, Pittsburgh, for western shipment; 1.50 cents, Chicago.
Sheets, 2.45 cents, net, for black and 3.50 cents, net, for galvanized, 28 gauge.
Tin plates, \$3.70 for 100-lb. cokes.
Wire nails, \$1.95, base; plain wire, 1.80 cents, base.

The Electric Furnace in the Steel Industry in Germany.

The abundance of articles on electric steel furnaces in the contemporary German engineering press is significant, especially as they are based on experience with electric steel making on a commercial scale. The two papers by Geilenkirchen and Osann (page 405 of this issue) give the experience of two German steel works, using the Heroult and the Roechling-Rodenhauser furnaces, respectively. B. Osann (*Stahl und Eisen*, May 6) reports on the satisfactory operation of the Stassano process in Bonn (Mr. Stassano's article in our August issue). Another novelty is the operation of electric furnaces on three-phase systems, like Mr. Straube's steel hardening furnace (page 410 of this issue). B. Neumann reports in *Stahl und Eisen*, Aug. 12 and 19, on a three-phase Roechling-Rodenhauser furnace in which some thousand tons of rails have been made and sold to German railways. We reserve a translation of this article for our next issue.

CORRESPONDENCE.

Steel Foundry Practice.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—I have written Mr. W. M. Carr, replying to his criticisms on my statements concerning steel foundry practice.

Mr. Wolff's latest word on this subject is so courteous, and his spirit so fair-minded, that I am sure it will now be patent to all steel-founders that he is not waging war on them, in a very proper effort to exploit the electric furnace.

GRANITE CITY, ILL.

R. A. BULL.

* * *

Electrochemical Processes for Central Stations.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—Your editorial in the September issue on the subject of "Electrochemical Processes for Equalizing Central Station Loads" opens up a subject that has for some time occupied the attention of progressive men in the two professions.

What you say is in the main, in my opinion, true, but there occur to me several objections or rather suggestions to your exposition of the question. It is to be hardly expected that central station men can sell power for a 20-hour day at less than 5 to 6 mills at their own switchboard, which means a considerably higher cost at the switchboard of the consumer. On the other hand, power can be produced at a coal mine or in the Western natural gas fields in large amounts for certainly less than one-half and possibly as low as one-third of these figures. In addition, power can be bought from different hydro-electric plants at an even lower price if in large amounts. In either case, the cost is such that it can be laid down as a fact that except in special instances, no electrochemical plant would care to use power at 6 mills with a considerable interval of idleness against a 24-hour use of power at 3 mills per kilwatt-hour at, we will say, Niagara Falls.

So it is my belief, that, save in special instances, where the cost of power is less than half the cost of total treatment, will industries yet to be born, start their little life in the more unfavorable environment.

But in industries using 150 to 300 kw where local conditions carry the balance to the other side, there should be a good field for the electric furnace in melting metals for casting or for refining waste products as well as in other ways. Anybody who can see what 100 kw-hours will do in a small electric crucible furnace can have a concrete example of its effectiveness in melting, welding and annealing metals.

Here, also, there is a snag. Any furnace that is to do rush work should be cheap and easily repaired. It should, of course, work with a tremendous amount of energy per cubic foot of active space. This will tend to increase the thermal and the commercial efficiency. As a general rule, people will not make any change in their plant if capital outlay is great. Furthermore, its special use will be found in small shops where a quick effective source of heat is needed *intermittently*. A host of such examples occur to my mind—such as small manufacturing jewelers and small repair shops. In this electricity will meet the competition of gas, with the numerous practical gas furnaces for just such uses already worked out and for sale at low figures.

It is useless to prophecy much, for I am neither a prophet nor a son of a prophet. But it is my belief that there will only be any considerable successful outlet for the surplus power of central stations, if the combined opinions of the electrochemist and the central station man realize these practical and commercial points and consider carefully the competition of gas in this direction as most formidable. Your journal will do a lasting and real service to the future of the central station by promoting the discussion of the question even with off-hand opinions such as this of mine.

NEW YORK CITY.

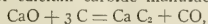
METALLURGICAL ENGINEER.

Electric Furnaces for the Manufacture of Calcium Carbide and Ferrosilicon.

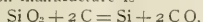
Dr. WALTER CONRAD, of Vienna, presented an interesting paper on this subject at the last general meeting of the Verein Deutscher Eisenhüttenleute in Düsseldorf. We herewith give a translation, slightly abstracted, of the paper and discussion. The full text may be found in *Stahl und Eisen* of June 3 and 10. This paper is naturally restricted to an exposition of the industries in Europe.

The commercial connection between calcium carbide plants and ferrosilicon plants is due to the fact that when the over-worked calcium-carbide boom collapsed in Europe in the beginning of this century, many of the existing carbide plants endeavored to find a more profitable production for their furnaces and began to make ferrosilicon in furnaces which were originally intended for carbide.

The formula for calcium carbide manufacture is



that for ferrosilicon manufacture is



Theoretically the production of 1000 kg calcium carbide requires 874 kg of caustic lime and 562 kg carbon. The production of 1000 kg silicon requires 2140 kg silica and 860 kg carbon; iron, added in any quantity, will alloy with the silicon to form ferrosilicon. In the carbide reaction 436 kg of carbon monoxide, in the ferrosilicon reaction 2000 kg are theoretically developed.

Aside from the similarity of the simple reaction equations, there are great differences between the two processes.

The calcium carbide process may be compared with a smelting process; at the high temperature of the furnace the calcium oxide becomes fluid and absorbs the carbon, forming a fluid bath of calcium carbide. On the other hand, the manufacture of ferrosilicon is a difficult reduction process. Fused quartz is not readily fluid; the fluid silicon which is formed has difficulty to pass through the sticky silica mass, especially in view of the low specific gravity of silicon. The process is facilitated by the addition of iron, the heavy iron drops running downward and carrying the silicon along.

In the carbide process the impurities are carried out of the furnace with the molten carbide. In the ferrosilicon process the impurities remain in the furnace and form a sticky slag high in silicon. It is impossible to use lime or other basic fluxes, because these would only increase the slag formation. The removal of the slag requires care; if the proper moment is missed, the furnace is filled with slag to an extent that tapping becomes impossible. It is then necessary to tear the whole furnace down and build it new.

In the beginning of the ferrosilicon industry serious mistakes were made in estimating the output. In the laboratory 4 kw-hours produced 1 kg of carbide yielding 300 to 310 liters acetylene. This corresponds to

- 6 kg per kw-day,
- 4.4 kg per electric hp-day,
- 4.0 kg per turbine hp-day.

If the year has 350 working days, this is equivalent to

- 2.1 tons per kw-year,
- 1.5 tons per electric hp-year,
- 1.4 tons per turbine hp-year.

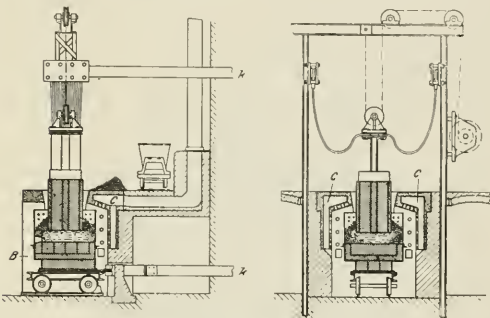
It was arbitrarily estimated that when operating on a large scale the output would be doubled. But, as a matter of fact, hardly two-thirds of the laboratory output was obtained. This was a bad disappointment.

The first furnaces, built by Gin and Leleux in Meran, by Schuckert in Jajce, Gampel and Hafslund, by Siemens & Halske in Lechbruck, by Bullier and others in France, were small crucibles on a carriage, as shown in Figs. 1 and 2. The bottom *B* of the crucible was one pole, while an electrode suspended in the crucible was the other pole, the connections to the external circuit being at *k*. The intention was to work continuously in these furnaces which were, therefore, provided with tap-holes.

A similar, but stationary, furnace was that of the Allgemeine Elek. Ges., the oldest type being shown in Fig. 3.

These oldest types of furnace offered many great difficulties on account of the dust evolved and the flames breaking out of the furnace. Tapping was very difficult, since around the walls of the hearth a layer of cold solid carbide formed of 10 to 20 cm thickness, which even when red hot, was as hard as good brick.

In the case of the movable furnaces on trucks, this difficulty was overcome by abandoning the method of tapping and remov-



FIGS. 1 AND 2.—OLDEST CARBIDE FURNACE AT MERAN (200 KW.).

ing the carbide in form of a block. But this method also offered great inconveniences.

Important progress was made when the bottom of the furnace was no longer used as one electrode, two vertical electrodes being suspended from the top. This type, called "series furnace," is shown in Fig. 5. With this construction the output was increased by 20 per cent.

The advantage of this arrangement is that when the two electrodes are raised, the formed carbide remains no longer in circuit (while with the former arrangement it acted as a series resistance consuming energy). In the older furnaces it was not possible to make larger blocks than 400 kg. while in the series furnace blocks of more than 1 ton could be produced. The loss of heat during cooling and the troubles attending the removal and cleaning of the carbide blocks remained, however, the same.

Those plants which used stationary furnaces had, of course, to devise means for properly tapping the furnace. While they have been finally successful in this respect, they have not been able to increase the output per unit of energy. Furnaces of this type are shown in Figs. 3 and 4. They are lined with carbon. The carbon bottom is one pole. It is directly in contact with the cast-iron foundation structure, which is made hollow to render artificial cooling possible.

FIG. 3.—OLDEST CARBIDE FURNACE. ALLG. ELEK. GES. (200 KW.)

The method of tapping with these furnaces was as follows: When a charge had been finished, no new material was added, but the supply of energy was continued with the result that one-fourth to one-third of the formed carbide was evaporated, dense fumes going off through the roof. At the same time the cold outside layer of carbide was melted to such an extent that through the tap-hole it became

possible to perforate the carbide layer from the outside. For this purpose an iron rod, electrically connected with the upper vertical electrode, was pushed through the tap-hole into the carbide. The arc which formed fused both the iron rod and the solid crust of carbide.

It was recognized in 1900 that to make real progress it would be necessary to use larger furnaces. The first furnace of this

broader and broader until finally the current passes not only through the charge, but through the incandescent furnace walls. It is then no longer possible to concentrate the energy. For processes with intermittent operation (like carborundum) this does not matter, but continuous operation becomes impossible under such conditions.

The effective remedy is found in the layer of vapor around the electrodes.* That this layer is the real zone of reaction is

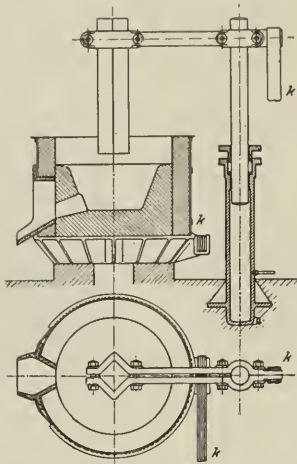


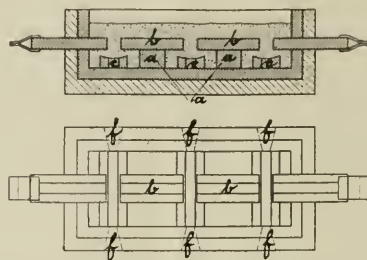
FIG. 4.—OLDEST MATREI FURNACE. (300 TO 500 KW.)

kind was that of Schuckert, of a capacity of 2000 kw, as shown in Figs. 6 and 7. The intention was to pass the current through the furnace in a longitudinal direction. Large blocks of carbon *b* were placed in the furnace so as to force the current into the desired path. These carbon blocks *b* were placed on blocks *a* of refractory insulating material. It was intended that the carbide should form at the terminal surface of the blocks *b* and should collect in the carbon hearths *c* below and flow off through the tap-holes *f*. However, this furnace was ill-fated; when it was started the furnace building was ignited by the exit gases and burned down.

According to our present knowledge of electric-furnace operation, the following principles must be fulfilled in the design of large furnaces for the manufacture of carbide and ferro-silicon.

First, the electrodes must not be in immediate contact with the charge; there must be a layer of vapor between electrode and charge, and this zone of vapor is the real zone of reaction. The importance of this condition will be recognized from the fact that at the high temperature of the furnace process all materials become conductors. At the high temperatures employed, the specific electric resistance of charcoal, quartz,

lime and magnesite becomes a few ohms (per meter length and square centimeter cross-section). The conductivity is, therefore, pretty good. In a furnace in which the electrodes are in electrical contact with the charge and walls, the voltage will, therefore, decrease with increasing temperature. At the same time the cross-section through which the current passes becomes



FIGS. 6 AND 7.—SCHUCKERT FURNACE. (2000 KW.)

proven by electrical measurements during operation. The voltage drop is essentially within this layer. Right at the surface of this layer, and only there, the carbide is formed. All designs of furnaces in which the electrode presses on the charge or rests on parts of the wall (like the Schuckert furnace of Figs. 6 and 7) are faulty. The simplest suitable construction is the very first one used by Siemens and employing a vertical electrode suspended from the top into a crucible.

Secondly, the most suitable furnace lining is obtained by cooling and slagging the layer of molten charge next to the walls. This layer is less destructible than any brick. Further, the introduction of any impurity from the lining into the charge is thereby avoided. The walls are artificially cooled from the outside by air or surrounded by metal plates which radiate the heat. For carbide furnaces, cooling with water is dangerous, on account of the possibility of formation of acetylene. In ferro-silicon furnaces cooling with water is largely employed.

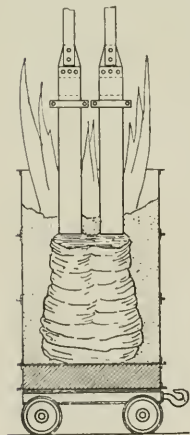
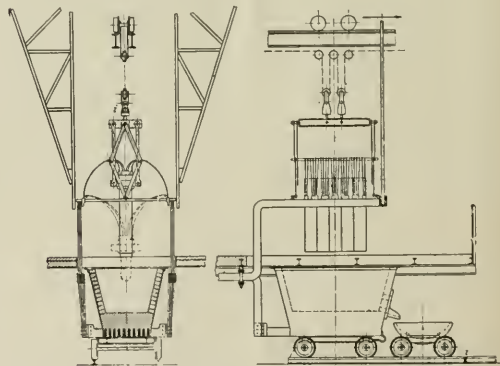


FIG. 5.—SERIES FURNACE. (450 KW.)



FIGS. 8 AND 9.—SWEDISH FURNACE FOR 400 TO 800 KWS

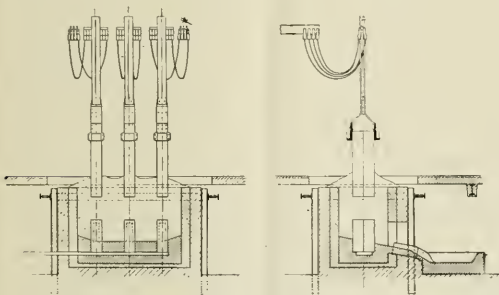
Thirdly, the bottom of the furnace should not be used as one terminal of the circuit. This third condition is, however, not universally recognized. In Sweden and Italy the bottom is still used as one terminal in carbide furnaces. The disadvantage is

*The author speaks of the "freibrennen der Elektroden," "free burning of the electrodes." He simply means that the electrodes when burning will produce a layer of vapor around their surfaces; this vapor zone prevents direct contact between electrode and charge, and in this zone the arc plays. When the arrangements are properly made, the electrodes will produce spontaneously this vapor zone.

the difficulty of getting a good contact between the iron foundation and the carbon bottom of the furnaces.

A very careful construction is illustrated in Figs. 8 and 9, showing a Swedish carbide furnace for 400 to 800 kw on a truck. A cast-steel grate is used as bottom, with a tar coal mass stamped in so as to make a good electrical contact. The side walls are made from sheet iron lined with a thin layer of a refractory material. The cooling system of the walls is perfect. The tap-hole is in one of the end walls; at this place the sheet-iron wall is strengthened by a cast-iron plate. This furnace is used exclusively for carbide manufacture. It would not be suitable for ferrosilicon, since the iron parts would be quickly destroyed by the spray from the outflowing metal. According to Dr. Conrad, the bottom is not used as a terminal in any modern ferrosilicon furnace.

The first attempts to make ferrosilicon in a furnace of several thousand horse-power capacity were made in the three-phase furnace shown in Figs. 10 and 11 ("the starting point of modern manufacture of ferrosilicon on a large scale"). It is a silica-brick furnace with steel girders, lined with firebrick. The bottom is made from stamped carbon in which is embedded a large iron plate, on which rest three electrode blocks rising above the furnace bath. They are arranged exactly below the three electrodes suspended from above.



FIGS. 10 AND 11.—THREE-PHASE FURNACE FOR 1200 KW.

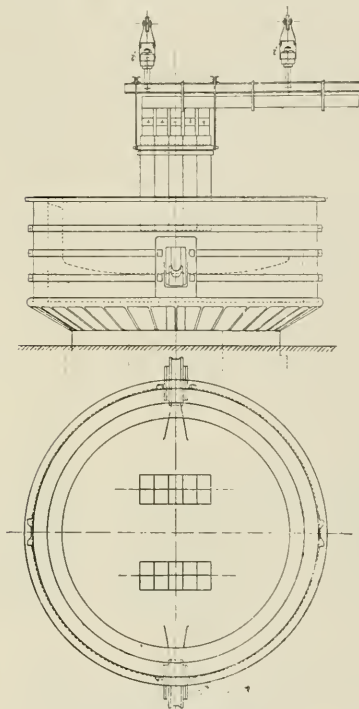
In the patent specification the lower electrode blocks were considered to be of great importance. It was expected that the ferrosilicon when formed there would flow off to a space filled with pieces of quartz. In this way the ferrosilicon would be quickly removed from the zone of the arc, so that evaporation would be avoided, and at the same time it was intended that the ferrosilicon should filter through the quartz pieces and that any carbon content in the ferrosilicon would be removed by the reaction between carbon and silica.

This hope was not fulfilled, however, in practice. The whole furnace contents became mashy and sticky, and the lower layer of silica lost its granular structure, which would be required for filtering. The ferrosilicon would make its own way and would preferably collect around the tap-hole, where some hollow spaces had been left from the last tapping operation. This resulted in a strong hydrostatic pressure upon the front wall, which would buckle. Cracks formed and the ferrosilicon ran down between the vertical layers of the furnace wall into the foundation of the furnace.

This was facilitated by the fluidity and low melting point of the ferrosilicon. It resulted in the destruction of the furnace wall. Nothing but carbon can withstand the chemical attack of ferrosilicon. If molten ferrosilicon drops fall on iron, the latter melts and dissolves immediately. Alumina, lime and all silicates form a glassy slag. If ferrosilicon gets in contact with stamped concrete, it will attack it and progress slowly, but without fail.

Further progress was made with the construction of the direct-current 3000-kw furnace of Figs. 12 and 13, which is an

almost perfect design of the year 1905. The furnace chamber is made so large that the brickwork is removed from the zone of greatest heat and the walls of the smelting zone, which are formed from the material of the charge, sintering together. The furnace is lined inside with carbon. The carbon of the bottom rests immediately on an iron bottom plate, which is provided with ribs for cooling. A layer of firebrick separates the carbon lining of the side walls from the outer iron sheets, which are bound together so that they may be tightened or loosened.



FIGS. 12 AND 13.—DIRECT-CURRENT SERIES FURNACE. (3000 KW.)

This furnace was in operation for more than a year; when torn down it was found to be in perfect condition. In view of the great distance between the tap-hole and the zone of reaction, the wall to be pierced through at the moment of tapping, became so thick that steel rod and hammer would no longer suffice, the slag being very hard even at red heat, while the iron rod then softens.

It was, therefore, absolutely necessary to solve the problem of tapping with the arc. The details may be seen from Figs. 14 and 15, which show a furnace for 4000 kw to 6000 kw. Furnaces of this type have recently been put in operation in Norway and Austria.

A is the small tapping carriage. The end of a rod of 6-m length holds the pointed tapping electrode, which is supplied with current through the copper cable *k*. With this arrangement it is possible to melt a hole through a carbide or slag block of half a meter thickness in 20 minutes.

The furnace itself is made of firebrick and lined with carbon.

A comparison of all the furnace designs shown in the above illustrations emphasizes their similarity and simplicity. "Aside from enlarging the size, no principal advance has been made in furnace design since Werner Siemens placed a small carbon rod in a graphite crucible." This is in marked contrast with the

infinite variety of furnaces designed on paper and described in patents.

Dr. Conrad urges that in examining patents on furnace construction, novelty should be considered of less importance than practicability. It should be proven that a certain construction can be carried out in practice, or has been carried out. Dr. Conrad thinks that all patents which have been granted should be declared void if their impracticability is afterwards proven.

Dr. Conrad then discusses at some length the different methods of making the connections between electrodes and the external circuit. He distinguishes between side connections (*zangenfassungen*) and head connections (*kopffassungen*). Side connections press against the sides of the electrodes so that a displacement of the electrode in the longitudinal direction is rendered possible. A side connection much used, is shown in Fig. 4; it consists of two water-cooled halves which grasp the electrode. As is well known, Héroult also used a side connection. With side connections any waste of electrodes may be avoided, if a new electrode is connected to the old one, as shown in Fig. 18. This makes no difficulty with soft electrode material since the two electrode pieces burn together immediately.

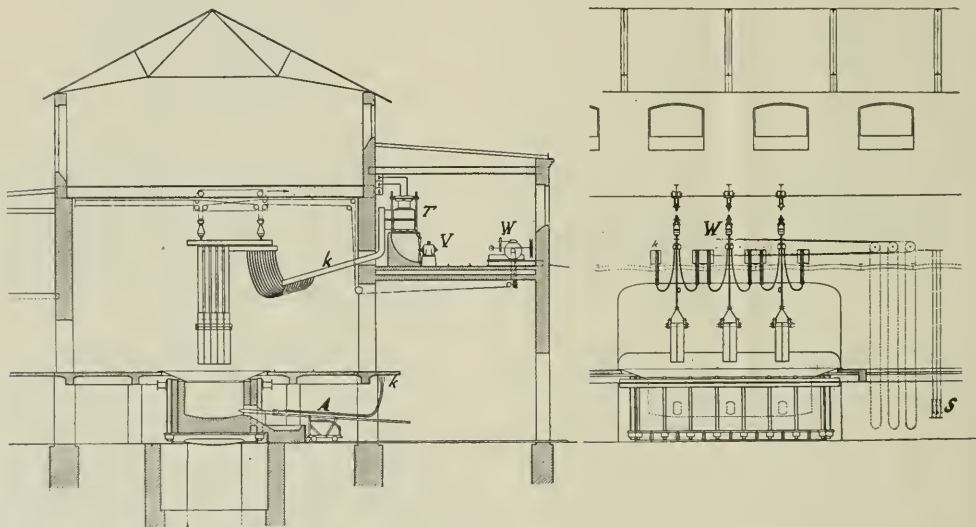
Side connections have the disadvantage that several electrodes cannot be assembled to form one package, while this is possible with head connections.

possible through the iron plate, so that at the lower rim of the latter the current density is a maximum.

Since one of the chief items of expense of electric furnaces is the copper for the conductors, it is important to make the conductors as short as possible. This has the further advantage of reducing the resistance and reactance of the conductors, thus diminishing the ohmic losses and phase difference.

Figs. 14 and 15 show an arrangement in which the total length of conductors from the secondary terminals of the transformers to the electrodes is only 13 m (43 ft.). In general it is difficult to place the transformers near the furnace without subjecting them to dust and heat, and without encroaching on the space around the furnace which is needed by the workmen. The best solution is to place the transformer on a high level, as shown in Fig. 14, where *T* are the transformers with the ventilators *V* for air-cooling. *W* is the motor for raising the electrodes and *S* the controller.

The difficulties are much greater when the furnace is supplied with energy not from a transformer, but directly from a generator. This arrangement must necessarily be used with direct current. For this reason alone, alternating current is preferable to direct current. In plants with which Dr. Conrad has been connected, the output per unit of energy was the same with direct-current and alternating-current operation and the carbide



FIGS. 14 AND 15.—THREE-PHASE FURNACE FOR 4000 TO 6000 KW.

The oldest and poorest head connection is the swallow-tail connection (Fig. 16). Its weak point is the final cracking off of the swallow-tail, as the result of tightening the screws. The construction of Fig. 17, in which the electrode is held by friction between two lateral plates, is better.

The head connection has undergone a peculiar development in Sweden, as shown in Figs. 20 and 21. The contact plates *a* are pressed against the electrodes by means of the wedges *b*. The latter are held in place by the longitudinal screws *c*, and these are prevented from lateral displacement by a series of cramps *d*.

Technically the most perfect head connection is that shown in Fig. 19, which has been developed in Italian plants. The water-cooled contact plate is pressed against the end surface of the electrode. Among all connections illustrated this is the only one which has a uniform current density all over the contact surface. With all other connections the current passes as far as

was of equal quality. On the other hand, ferrosilicon made in alternating-current furnaces is purer, because in direct-current furnaces electrolysis of the charge reduces calcium, aluminum and other metals which thereby get into the ferrosilicon.

For the fixed portion of the secondary circuit it is preferable to use copper ribbon of 150 mm to 300 mm breadth and 7 mm to 15 mm thickness. To reduce the self-induction, the well-known method of transposition of the conductors may be used. This arrangement is used with the furnace of Figs. 8 and 9. In this case the two conductors of opposite sign come together from the transformer room and separate into a conductor going upward and another one leading downward right at the furnace.

The conductor leading downward is connected by means of copper pole-shoe directly to the cast-steel grate of the furnace bottom. The conductor leading upward is connected to a flexible copper cable leading to the electrode. The details may be seen from Figs. 20 and 21.

The flexible cables are supported by the rods *c*, which are held by shears in such a way that when the electrodes are raised or lowered the rods *c* are raised or lowered only half the distance.

Though the arrangement is ingenious it has the disadvantage that the bending of the cables and their rubbing against the supporting rods causes excessive wear and tear. A further disadvantage is that the flexible copper cables, which are made of wires of 0.7 mm thickness, soon oxidize and burn through when exposed to the heat of the furnace and the furnace gases. It is, therefore, preferable to use nothing but copper bars above the furnace and to place the flexible part of the connection outside of the furnace. This arrangement is used in Figs. 12, 13, 14 and 15.

In order to prevent a serious reduction of the power factor it is important to avoid the induction of alternating currents in closed iron circuits. The Swedish furnaces of Figs. 8 and 9 suffer from this trouble, while the three-phase furnaces 10 and 11, 14 and 15 are almost free from it. Even if closed iron-circuits are carefully avoided, eddy currents will be induced in practically every piece of metal in the furnace room. This may involve some danger, for instance, when as a result of eddy currents the chains holding the electrodes become red hot and loose their strength.

With the old small furnaces the supply of electrical energy to the furnaces reacted in a troublesome way on the lighting network on account of the sudden variations in the furnace load. Variations of current and voltage by 10 per cent were usual. On the other hand, the large modern furnaces have a load as regular as a constant-load motor of equal capacity. Regulation of the current is necessary only during tapping and during changing of the electrodes. While it may not be advisable to operate electric furnaces in parallel with the lighting network of a city, there is no trouble whatever in operating the furnaces in parallel with the lighting and power network of the works. The furnace itself is absolutely indifferent to any variation of voltage or speed of the motors.

The raw materials of carbide manufacture are burnt lime or limestone, and coke, charcoal or anthracite; those of ferrosilicon manufacture are quartz, charcoal or anthracite, and iron. If these raw materials contain too many impurities, the carbide produced will yield less acetylene per pound of carbide; on the other hand, ferrosilicon manufacture becomes impossible with too many impurities in the raw material.

The most serious impurity for both carbide and ferrosilicon manufacture is phosphorus, since in the decomposition of the products phosphuretted hydrogen is produced which may lead to explosions and poisonings. For this reason specifications for carbide contain a requirement as to the maximum content of phosphuretted hydrogen in acetylene. European railways and steamship companies have also recently made more stringent regulations on the transportation of ferrosilicon.

It is, therefore, important to avoid raw materials containing phosphorus, and for this reason especially coke and cast iron containing phosphorus cannot be used.

While in the early days of the industry much attention was paid to careful grinding of the raw materials, it is now usual to use charcoal unbroken, lime, quartz and coke reduced to pieces not less than 4 cm. In large furnaces pieces as big as a fist or a head may be successfully used.

"Of greatest importance for the financial result is the power consumption. In well-managed plants the production of 1 kg of carbide requires 4 kw-hours; that of 1 kg of silicon, 12 kw-hours, so that 1 kw-day will produce 6 kg of packed carbide and 4 kg of ferrosilicon of 50 per cent.

"The water-power plants of the Alps and Norway operate with a power cost of 0.1 to 0.25 cent per kw-hour, so that the cost of power is \$4 to \$10 per ton of carbide and \$6 to \$15 per ton of 50 per cent ferrosilicon. But the location of the large water-power plants is often unfavorable for the supply of the raw materials and for the marketing of the products.

"Steam plants operating near the market have the advantage of lower freight expenses." Under average European conditions this advantage is figured out in dollars and cents by Dr. Conrad as follows: "For the production of one ton of carbide there are required two tons of raw materials. For the production of one ton of 50 per cent ferrosilicon there are required 2.7 tons raw materials. Each ton of product, therefore, involves freight for three to four tons to and from the works, costing at least \$2.50 per ton. Hence, a favorably-situated steam plant saves from \$7.50 to \$10 in shipping expenses per ton of finished product, compared with an unfavorably-situated water-power plant. By this amount the steam power may be more expensive than the water power without increasing the total cost. This gives a difference of 0.175 cent per kw-hour." In the case of the carbide industry it is also to be taken into account that when the factory is located near the consumers, one-half or two-thirds of the cans are returned and may be used again, which means another saving.

As long as the output of carbide and ferrosilicon per unit of electrical energy was low, the power cost was so important that competition of steam plants with water-power plants was out of the question. But with the gradual improvements of the processes the efficiency has been raised to such an extent that both manufactures may now be successfully carried out in coal regions and metallurgical districts, especially if steam turbines are employed and if cheap and good raw materials are available. As a matter of fact, carbide plants have already been erected in European coal districts.

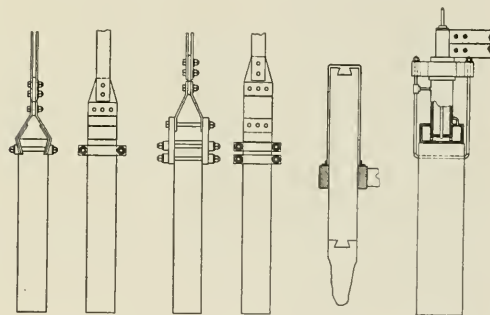


FIG. 16.—SWALLOW-TAIL CONNECTION. FIG. 17.—SIDE PLATES.
FIG. 18.—ATTACHMENT OF ONE ELECTRODE TO ANOTHER.
FIG. 19.—ITALIAN HEAD CONNECTION.

The market for calcium carbide is steadily growing, not only for acetylene lighting plants, but for the use of acetylene for welding, heating and cooking, and for chemical purposes. There is also good prospect that the manufacture of calcium cyanamide will soon consume important quantities of carbide. For lighting in mines acetylene is ideal and should be generally used.

The ferrosilicon market is just at present in a bad condition as a result of the crisis in the iron and steel industry.

Dr. Conrad appears to look favorably on the erection of ferrosilicon plants by the steel companies themselves. He thinks the present crisis is favorable to such work. He also thinks that the ferrosilicon industry would profit thereby. It has been developed in the past by chemists and mechanical engineers. The co-operation of steel metallurgists would necessarily bring good results.

* * *

Dr. Conrad's paper elicited an extended discussion which was opened by Geheimrat Prof. WEDDING, who spoke here for the last time before his death. He asked several questions: Why does the steel industry not use so large electric furnaces as the carbide industry? Why are induction furnaces not used in the carbide industry? The Héroult furnace is essentially an arc

furnace. Even if the ends of the electrodes are within the upper layer of the slag there will be a layer of gas around them through which the arc plays from the electrode to the slag, as described in Dr. Conrad's paper for calcium carbide. In the Héroult furnace the arc heats the slag from above, and this is an advantage over the induction furnace.

Dr. CONRAD replied that in the steel industry a temperature of 2000° is required, which can be easily obtained in the induction furnace. On the other hand, formation of carbide and fusion of quartz require a much higher temperature, say, 3000° C. This cannot be produced in the induction furnace. The reason is that at this temperature no lasting and non-conductive furnace lining is available. When in the induction furnace the temperature is raised more and more, the furnace lining begins to conduct and the current is no longer restricted to its proper path. Formation of carbide and reduction of silica occurs only at highest current density within the zone of the arc. There is nothing like this in the induction furnace. In the induction furnace no temperature like that of the arc can be produced.

In the Stassano furnace the arc is formed a few decimeters above the bath in the free upper space of the furnace and the heat is thereby radiated from above in the same way as is the case in the open-hearth furnace. On the other hand, in the Héroult furnace the source of heat is in the slag itself directly above the steel bath. In this way it must be possible to get a higher temperature of reaction. In the Héroult furnace the liquid slag is the top layer of the contents of the furnace. In the carbide furnace and in the ferrosilicon furnace the fused bath is covered with raw material which is being preheated and only partly softened or fused. The electrodes pass through this raw material without giving off any appreciable amount of current to the surrounding material. This material prevents the electrodes from burning off and also protects the upper parts of the brickwork of the furnace from the intensive heat of the arc.

Dr. GELENKIRCHEN spoke of results obtained in the steel works of Richard Lindenberg, in Remscheid, with the Héroult furnace. The danger that parts of the carbon electrodes might break off and fall into the steel bath exists only on paper. The terminals of the electrodes are not within the slag, but above the surface of the same, and the length of the arc is regulated by the mechanism raising and lowering the electrodes. Since the electrodes are vertical they themselves protect the upper part of the furnace from the heat of the arc. This is an advantage over the Stassano furnace in which the electrodes are not vertical.

Mr. B. KUTSCHE spoke of the results obtained in the Bonner Fraeser Fabrik with the Stassano furnace during the last five months. This furnace consumes 800 kw-hours for melting 1000 kg of soft wrought iron, and from this the speaker calculates a thermal efficiency of 88 per cent. As this is very high, an increase of the furnace would only diminish the radiation losses, while with increase of size it would become more and more difficult to maintain the electric losses and the heat loss due to the cooling of the electrodes within proper limits. For this reason there is no advantage in increasing the furnace beyond a certain size. In the Stassano furnace the electrodes are not horizontal, but inclined downward. The arc plays downward toward the slag on the steel bath.

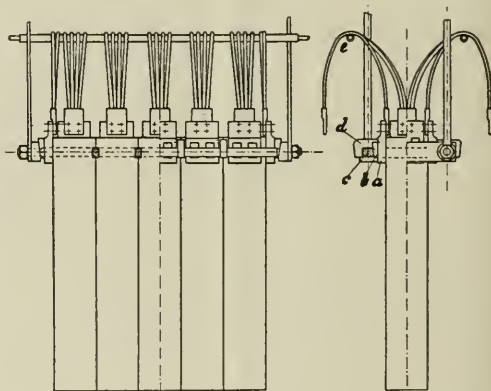
In reply to Prof. Wedding's question why the steel industry does not use as big furnaces as the carbide and ferrosilicon industries, Mr. Kutsche pointed out that the production of one ton of ferrosilicon requires 25 times the electric energy necessary for refining a ton of liquid steel. While the carbide industry uses furnaces of 6000 kw, an electric-steel furnace of 6000 kw would contain charges of 50 to 60 tons. There is not yet a commercial demand for such large quantities of steel of high quantity. Further, as explained before, the smaller electric furnaces are quite satisfactory.

Prof. EICHHOFF emphasized that Héroult never had the intention to heat the steel bath by the Joulean heat of the slag alone. The Héroult furnace is practically an arc furnace. The

resistance of the slag and bath produces only a few per cent of the total heat. He does not think it is possible to have an efficiency of 90 per cent in an electric steel furnace. There are always losses due to radiation and other causes.

According to Prof. Eichhoff if the thermochemical calculation is made, it is found that in a 1000-kg furnace less than 50 per cent of the calories supplied to the furnace are utilized. Small electric furnaces have hardly a higher efficiency than 50 per cent. When the size is gradually increased the efficiency may be increased to 70 per cent, or even 75 per cent, because the volume increases more quickly than the surface. In his practical experience he found that by increasing the size of furnace from a 1500-kg to a 3000-kg furnace the consumption of energy was increased by 10 per cent only. The consumption of energy per ton of steel increases considerably with the size of furnace. Furnaces for 15 tons are just as reliable and safe as smaller furnaces for 2000 or 5000 kg.

Prof. Eichhoff said the prevailing opinion was wrong that electric furnaces were suitable only for producing high-quality steels. The cost of production has been reduced so much that in a 5-ton furnace the poorest raw materials may be used to make steel of best quality with 200 kw-hours per ton of steel. And if it is not intended to produce steel of highest purity in large furnaces, it will be possible to reduce the energy consumption to 150 or even 120 kw-hours per ton of steel. Under these circumstances the cost of electric energy is insignificant in view of the higher quality of the steel produced. Such steel will be used for many purposes, even rails.



FIGS. 20 AND 21.—CONNECTION FOR FURNACE IN SWEDISH PLANT.

Mr. VOGEL called attention to the fact that ferrosilicon is not only used in the steel industry, but is also used as a raw material for making apparatus, pipes, etc., for chemical works, since they resist successfully the attack of acids of any kind (see the paper by A. Jouvé on "Metallure" alloys in our August issue, page 321). Ferrosilicon containing 75 to 80 per cent of silicon is unattackable by acids. The problem is to make this alloy on a large scale and bring it into the desired forms. The success so far obtained is quite promising.

Dr. O. WEIL pointed out that the production of high-percent-age ferrosilicon or silicon with a purity of 90 to 95 per cent should bring good financial results. He referred to the production and uses of calcium silicide recently patented by Dr. Hans Goldschmidt for purification of metals and especially steel. (See the article of Dr. Goldschmidt in our June issue, page 244). A very large amount of aluminium is used every year in the steel industry for just that purpose for which calcium silicide is even more suitable. If only a part of this aluminium is replaced by calcium silicide there would be a large demand for silicon.

On Methods of Obtaining Cooling Curves

By G. K. BURGESS.

(Concluded from page 371.)

Direct and Inverse Rate Curves.

V. θ vs $d\theta/dt$.—In many problems it is of interest to measure the speed of the transformations under observation. This may be done by determining directly the rate of change of temperature of the sample in terms of its temperature. Le Chatelier²² used this method in 1887 in his study of the properties of clays.

He was also the first to employ a photographic apparatus for the recording of cooling or heating curve data, using an arrangement in which the plate remained stationary. The sparks from an induction coil were made to pass at intervals of two seconds before a slit and gave upon the plate, after reflection from the galvanometer mirror, images of the slit whose spacing was a measure of the speed of heating, which in his experiments was about 2° C. per second.

Another method of recording the rate of heating or cooling in terms of the temperature has been devised by Dejean.²³ The new feature of this method is the use of an induction galvanometer or relay which may be inserted in the circuit of the more sensitive galvanometer G_1 of the Saladin system (Fig. 8). The principle of the apparatus is shown in Fig. 9. The induction relay is a modified d'Arsonval galvanometer having an electromagnet and a movable coil, the latter consisting

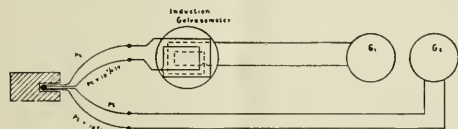


FIG. 9.—DEJEAN METHOD.

of two distinct insulated windings, one of which is connected to a thermocouple.

Heating or cooling one junction of this couple causes the coil to be deflected and its motion in the field of the electromagnet induces an e.m.f. in the second winding of the coil which is proportional to its angular speed and hence to the rate of change of e.m.f. of the couple, or approximately to the rate of cooling or heating, i. e., to $d\theta/dt$.

The induced e.m.f. is measured by joining this winding to the sensitive galvanometer G_1 . The galvanometer deflection passes through a minimum when the heating or cooling passes through a minimum, that is, for a region in which there is an absorption or evolution of heat. A second thermocouple in series with the other galvanometer G_2 of the Saladin system gives the temperature of the sample.

We have, therefore, on the plate P (Fig. 8), when the record is taken photographically, the temperatures as abscissae and the rate of change $d\theta/dt$ as ordinates, as shown in Plate I, Fig. V.

Dejean has used this method in the study of steels and has also investigated with it the copper-cuprous oxide system. The transition temperatures are very sharply marked. If desired, direct reading may be substituted for the photographic recording, with an increase in precision. This method is evidently a perfectly general one for recording the rate of change of e.m.f. (de/dt).

For neither Le Chatelier's nor Dejean's arrangement can differences in the rate of heating or cooling due to the substance itself be distinguished from those due to external causes, since no neutral piece is used.

VI. θ vs dt d θ .—Among the methods adapted for slow cooling, we shall mention last one of the earliest which was used to

throw into prominence the abnormalities of a cooling curve, namely, the *inverse rate method*, which was employed as early as 1886 by Osmond²⁴ in his classic researches in metallurgy. It consists in noting the intervals of time required for a substance to cool by equal decrements of temperature and plotting this quantity ($dt/d\theta$) in terms of the temperature. (See Plate I, Fig. VI.)

Osmond thus describes his method: "The time taken by the thermometer during the heating or cooling of the sample to rise or fall one division of the scale (1 mm) was registered by means of a Morse telegraph ribbon, or on a rotating cylinder turned by a small electric motor. . . . A halt of the thermometer is transcribed as a cusp and a slowing down by a swell of the curve, whose area is proportional to the quantity of heat set free."

But one thermocouple is needed and no neutral piece is used so that the apparatus is the same as required for a θ vs t curve; I, although it is necessary, if work of precision is to be undertaken, to record very exactly by means of a chronograph and key the intervals of time (Δt) required to pass over a given number of degrees ($\Delta\theta$), say 5° C. or 10° C. intervals.²⁵

The method, however, cannot readily be made automatically recording for the variables θ and $dt/d\theta$ in terms of each other,

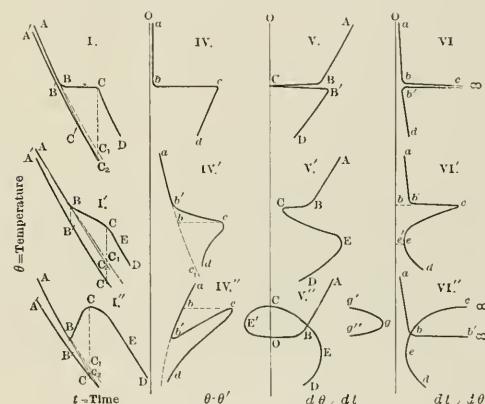


PLATE I.—TYPES OF COOLING CURVES.

and, therefore, requires the active presence of the observer. It has the same disadvantage as method II, in that the precision of a difference in temperature ($\theta - \theta'$ or $\Delta\theta$) can be made no greater than that of the temperature θ . The inverse rate method is perhaps best considered as one for interpreting and plotting the θ vs t data in such a way as to emphasize its irregularities and so the more readily permit the detection of any critical regions.

Rapid Cooling.

None of the experimental arrangements so far described is adapted for measuring the very rapid cooling, i. e., several hundred degrees in a few seconds, met with in quenching or chilling.

Le Chatelier,²⁶ in an investigation of the quenching of small samples of steel and the effect of various baths, made use of a galvanometer having a period of 0.2 seconds and a resistance of 7 ohms, whose deflections were recorded on a photographic plate moving vertically at a speed of 3 mm per second. A half second's pendulum vibrating across the path of the beam of light, from a Nernst glower as source, gave a measure of the time. He succeeded in recording satisfactorily temperature in-

²⁴F. Osmond, *Comptes Rendus* (Paris), 103, p. 743, p. 1122; 1886, 104, p. 985; 1887. *Annales des Mines*, 14, p. 1; July, 1888.

²⁵This method is well illustrated by F. Wüst, *Metallurgie*, 3, p. 1; 1906.

²⁶H. Le Chatelier, *Rev. de Metallurgie*, 1, p. 473; 1904.

²²H. Le Chatelier, *Comptes Rendus* (Paris), 104, p. 1443; 1887.

²³P. Dejean, *Rev. de Metallurgie*, 2, p. 701; 1905. 3, p. 149; 1906.

tervals of 700° C. in six seconds, using as samples cylinders 18 mm on a side.

It would be desirable to increase the precision and sensitivity of this method, which might be done, as Le Chatelier himself suggests, by using an oscillograph arrangement, or a string galvanometer, such as Einthoven's, in which the displacements of a silvered quartz fiber of high resistance in an intense magnetic field are measured photographically.

Characteristics of Cooling Curves.

In conclusion, let us consider briefly the forms that the different cooling curves may take and their approximate interpretation, for three typical kinds of transformation:

- The substance remains at a constant temperature throughout the transformation.
- The substance cools at a reduced rate, which may or may not be constant over a portion of the transformation.
- The substance undergoes an increase in temperature during the first part of the transformation.

An approximation to the first case, that of a strictly isothermal transformation, is met with in the freezing of chemically pure substances of sufficient thermal conductivity which do not undercool appreciably; in the formation of eutectics, and occasionally in other transformations. The second case is perhaps the most common; and the third is represented by the phenomena of recalescence and of undercooling preceding crystallization.

In the case of an isothermal transformation (a), heat is generated at the same rate that it is lost by radiation, convection and conduction, or, considering the phenomena as confined to the sample alone:

$$dQ/dt = \dot{M}s \, d\theta/dt \quad (\alpha)$$

where M is the mass and s the specific heat of the body supposed constant during the transformation, dQ/dt the rate of generation of heat, and $d\theta/dt$ the rate of cooling the body would have, when passing through the temperature of the transformation, if there were no transformation. The heat Q generated in such a transformation lasting a finite time Δt , is, therefore:

$$Q = Ms \Delta t \, d\theta/dt \quad (\beta)$$

in which $\Delta t \, d\theta/dt$ is a measure of the fall of temperature, $\Delta\theta$ the substance, would undergo if there were no evolution of heat during the time Δt , that is, during the transformation, whence:

$$Q = Ms \Delta\theta \quad (\gamma)$$

In the case of the transformation (b) we have

$$dQ/dt < Ms \, d\theta/dt$$

and for the transformation (c)

$$dQ/dt > Ms \, d\theta/dt.$$

In Plate I are illustrated these three types of transformation as given by the following cooling curves:

I. θ vs t Temperature-time.

IV. θ vs $\theta - \theta'$ Differential.

V. θ vs $d\theta/dt$ Temperature-rate.

VI. θ vs $dt/d\theta$ Inverse rate.

The first horizontal line of figures refers to case (a), the second line to (b), and the third line to (c). For all of the curves the ordinates are temperatures; and the corresponding parts of the several curves are indicated by the same letters. The vertical lines o, o' represent the zero of abscissae for each group of curves.

In the case of the temperature-time curves, Figs. I, I', I'', they are drawn for an accompanying neutral piece, A'B'C', as well as for the sample under study, A B C D. In I the sample and neutral are cooling at the same rate, while in I' and I'' they are cooling at different rates. In each figure the point C_1 indicates the temperature that would have been reached by the sample if there had been no transformation. C_1 may be considered as practically coinciding with C_2 , the temperature that would have been reached if the sample had continued to cool at the same rate as at B, the beginning of the transformation.

For each of these transformations (a), (b) and (c), as represented by the curves I, I', I'', the heat evolved is approximately proportional to $\Delta\theta = CC_1 = CC_2$, or the maximum dif-

ference in temperature produced by the phenomenon. It is to be noticed that in general the rate of cooling just to right of C will be greater than that just to the left of B, on account of the presence of the furnace; for the furnace walls, to which the heat is being lost, have continued to cool during the time B C. Even if the furnace were at a constant temperature, the rates at B and C might still be different due to the difference in specific heats and in emissivities of the substance before and after the transformation. The end of a transformation is always marked by a point of inflexion, as shown at E (Figs. I', I'').

From the temperature-time curve, therefore, we may determine the temperatures of beginning and ending of a transformation, its duration, an approximate measure of the heat evolved by the transformation, as well as the rate of cooling, and, therefore, of transformation, at any instant. The interpretation of the variations in these factors forms the basis of thermal analysis, which has begun to be so productive in the determination of the constitution of alloys and chemical compounds.²⁷

Although the forms of the curves representing the various methods are those corresponding to what is actually obtained from a sample cooling inside a furnace, yet it should be noted that the equations representing the evolution of heat are written in a form that practically neglects the influence of the furnace.

A complete discussion of the cooling within a furnace of a substance possessing transformation points would be more complicated than contemplated by this paper, requiring a knowledge of the law of cooling of the furnace and that of the interchange of heat between the sample and the furnace, the latter depending on their relative heat capacities and conductivities, the emissivity of the sample and the distribution of temperature within the furnace.

If small quantities of heat are involved in a transformation, the simplest assumptions that can be made are that at each instant the sample is losing heat to the furnace at a rate proportional to their difference in temperature, and that the parts of the furnace receiving this heat are all at the same temperature throughout at any instant. On this basis, the quantity of heat Q , lost by the sample during a transformation, as interpreted by the θ vs t curve, would be more nearly proportional to CC_1 than CC_2 .

The practical conditions of cooling, however, are in general somewhere between the two extremes of the sample cooling independently of the furnace as required by our equations, and within the simplified furnace above described; so that CC_1 may be considered a minimum measure of the heat evolved, the actual measure of this quantity varying with every different experimental arrangement.

In what follows, the limitations just discussed, concerning the measurement of the heat evolved during a transformation, are assumed to apply to each of the types of cooling curve.

Figs. IV, IV' and IV'' give the forms of the curves traced when the difference in temperature ($\theta - \theta'$) between the sample and the neutral piece of approximately the same thermal capacity is plotted in terms of the temperature (θ) of the sample. In Fig. IV the line bc, since it is the approximate equivalent of $CC_1 = \Delta\theta$ of Fig. I, may be taken as a measure of the heat evolved during the transformation.

If the cooling curves of the sample and of the neutral are not parallel, as shown in Figs. I' and I'', it is necessary, in estimating the heat evolved from the difference curve ab'cd (Figs. IV' and IV'') to take into account the variations in $\theta - \theta'$ during the transformation. This change in $\theta - \theta'$ is given by BB'—C,C' (Figs. I', I'').

Furthermore, successive differential curves for the same sample are comparable only when the sample and neutral are

²⁷ The principles of thermal analysis as based on the θ vs t curve are quite fully described in the following papers by Tamman: *Zs. Anorg. Chem.*, 37, p. 303; 1903. 45, p. 24; 1905. 47, p. 289; 1905, a résumé of which is given by Forstner in *Rev. de Metallurgie*, 4, p. 970; 1907. See also Bancroft, *Jl. Phys. Chem.*, 6, p. 178; 1902. Shepard, *ibid.*, 8, p. 92; 1904. Iron and Steel Mag., 8, p. 222; 1904, and Bakhuys Roozeboom, *Die Heterogenen Gleichgewichte*, 1901.

cooled in the different experiments so as to always maintain the same temperature-time relation over a given range. When this is the case, be (IV' and IV'') is still an approximate measure of the heat generated.

It can be shown that, except for horizontal tangents, the points of inflexion E of the θ vs t curves do not correspond to points of inflexion at the same temperatures on the differential curves, hence the end of a transformation cannot be determined from the latter. If equal time intervals are marked on the differential curve, the rate of cooling or of transformation over an interval Δt may be obtained by finding the value of $\Delta\theta/\Delta t$.

Although, as we have seen, the differential method may be made more sensitive and certain than the direct method, yet, from the above, it is evident that it furnishes a less complete basis for the interpretation of the physico-chemical phenomena involved in the indicated transformations.

Figs. V, V', V'' represent the *temperature-rate* curves (θ vs $d\theta/dt$), and Figs. VI, VI', VI'' the *inverse-rate* curves (θ vs $dt/d\theta$). The two types may be considered as reciprocals of each other. Comparing them with the θ vs t curves (Figs. I, I', I'') it is seen that a sharp break in the latter corresponds to a perpendicular to the temperature axis for both the former; and that for an isothermal transformation, $d\theta/dt$ becomes zero at C and $dt/d\theta$ infinite at c. When the θ vs t curve is convex to the θ axis, the $d\theta/dt$ curve is concave and the $dt/d\theta$ curve convex. Both curves give negative values (OE'C, Fig. V'', and g'gg'' Fig. VI'') for a region of recalescence.

The end of a transformation, corresponding to a point of inflexion E on the θ vs t curve, is sharply indicated (E, e) on both these rate curves by the tangent becoming parallel to the θ axis and the curve having a maximum or minimum abscissa. For any region of cooling at a constant rate, the tangent remains parallel to the θ axis during this interval.

From neither of the rate curves can the relative amounts of heat evolved during a transformation be readily computed for the different kinds of transformation. The area of the inverse-rate curve, however (Fig. VI'), taken between the limits b', e', is proportional to Δt , or to $Q d\theta/dt$ (see equation β), that is, to the quantity of heat generated divided by the rate of cooling.²⁸

If the rates of cooling at the beginning of two transformations are equal, then the areas, taken as above for the inverse-rate curves (Fig. VI'), become an approximate measure of the heat generated. This condition, however, is rarely realized in practice. An examination of Fig. VI'' shows the practical impossibility of constructing any instrument other than one using an optical system for recording the complete inverse rate curve.

We see, therefore, that both these rate curves mark the limits of a transformation more sharply than either the temperature-time or differential curves, and, in general, show greater changes in form for slight heat changes, but the rate curves do not, in general, give a simple measure of the heat evolved, nor is a neutral piece used to eliminate extraneous heat fluctuations.

A comparison of the properties of these various cooling curves indicates that the one from which the most comprehensive view of a transformation can be obtained is the simple temperature-time curve (I) when this method is made sufficiently sensitive; the one giving the least information is the temperature-rate curve (V); and those which cannot readily be recorded directly by any form of instrument yet devised are the inverse-rate curve (VI) and the derived differential curve (IVa); while the one that can be made the most sensitive and certain is the differential curve (IV).

The analytical discussion, therefore, leads to the same result as the examination of the experimental methods, namely, that for great range, combined with greatest sensitiveness, the most certain and complete data may be obtained by combining the temperature-time observations with those obtained by the differential method.

BUREAU OF STANDARDS, WASHINGTON, D. C.

Removal of Sulphur in Electric Steel Furnaces.

The removal of sulphur in electric furnaces for steel refining has been the subject of two recent independent investigations, of which one has been carried out by Dr. TH. GEILENKIRCHEN in the daily practice with the Héroult furnace in the steel works of the Rich. Lindenberg Co. in Remscheid-Hasten, while the other research has been made by Prof. BERNHARD OSANN with a 1000-kg Roechling-Rodenhauser modified induction furnace in the Roechling works in Voelklingen. These two papers may be found in full in *Stahl und Eisen* of June 17 and July 15 respectively.

The fact that an effective removal of sulphur takes place in the Héroult furnace is proven by Dr. GEILENKIRCHEN by the following results of 1000 successive charges in the ordinary daily practice of the Rich. Lindenberg Co. Of these 1000 successive charges, the steel produced in

88 charges	contained up to	0.001	per cent.
5	"	"	"
14	"	"	"
39	"	"	"
50	"	"	"
82	"	"	"
100	"	"	"
168	"	"	"
99	"	"	"
108	"	"	"
67	"	"	"
64	"	"	"
35	"	"	"
29	"	"	"
20	"	"	"
11	"	"	"
14	"	"	"
6	"	"	"
2	"	"	"
1	"	"	"
2	"	"	"
2	"	"	"
2	"	"	"
1	"	"	"
1	"	"	"

It will be seen that 74.3 per cent of all charges gave a steel containing not more than 0.010 per cent S, while 95.8 per cent of all charges gave a steel containing not more than 0.015 per cent S.

These good results were not due to the use of especially pure raw materials, as is proven by the following figures which give the percentage of sulphur in the liquid steel charged into the electric furnace for refining during the same period:

0.114	0.133	0.035	0.099	0.055	0.069
0.076	0.204	0.070	0.500	0.075	0.131
0.050	0.100	0.058	0.037	0.070	0.450
0.158	0.064	0.142	0.086	0.043	0.060
0.056	0.123	% S.			

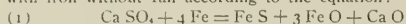
To give the metallurgical rationale of the removal of sulphur in the Héroult furnace, Dr. Geilenkirchen first compares the latter with the basic open-hearth furnace. In the molten steel bath sulphur is chemically combined with iron and manganese. These sulphides are soluble both in the steel bath and in the slag. The amount of sulphides passing into the slag is determined by the general laws of the equilibrium between two solutions, with different solvents but the same solute. The principal rule is that the quantity of sulphides passing into the slag will be the greater, the higher the temperature, the basicity of the slag and its content of lime and manganous oxide.

These conditions can be easily fulfilled in the Héroult furnace. The temperature of the slag below the arc is exceedingly high. It is, therefore, possible to make the basicity of the slag at will as high as desired. It is especially possible to make the content of lime considerably higher than in any other process. Under these circumstances the removal of sulphur in the Héroult furnace in the way sketched above must proceed much further than in the basic open-hearth furnace. Nevertheless it cannot be complete from this single point of view, because according to the laws of equilibrium sulphides must always remain in the steel bath as long as the latter is in contact with a slag containing sulphides. Of course, by renewing the slag and using a new slag free from sulphur, more sulphur will be removed from the steel bath. But this method takes time and is expensive.

If the sulphur is to be removed completely, it is necessary to

²⁸ The area b'bec'e' = $t_2 - t_1 = \Delta t$, or the time occupied in falling a temperature $\Delta\theta$.

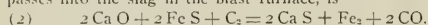
bind it quantitatively in form of a sulphide insoluble in the steel bath. The only sulphide which is to be considered is calcium sulphide. But if calcium sulphide is present in the slag, it has a great tendency to oxidize and form the sulphate CaSO_4 . According to Finkener's experiments this will react with iron without fail according to the equation:



The sulphur then passes back into the steel bath.

It is even worse in the open-hearth furnace. Any sulphur dioxide in the flame gases, due to the sulphur content of the fuel, will tend to oxidize to sulphur trioxide and combine with the lime of the basic slag and form calcium sulphate. The latter then reacts according to the above equation, so that the final result is that a part of the sulphur in the fuel will pass into the flame gases, then into the slag and finally into the steel bath.)

With respect to the change of iron sulphide into calcium sulphide, it is known that it requires the presence of a strong reducing agent. For instance, the reaction by which sulphur passes into the slag in the blast furnace, is



The same reaction may take place in the open-hearth furnace with simultaneous reduction of the carbon content of the slag; it will take place directly at the contact surface between steel bath and slag. The same reaction will also occur in the Héroult furnace if high-carbon and high-sulphur steel is treated. However, the easiest way of operating a Héroult furnace is to feed it with molten decarbonized and overoxidized iron so that the conditions for the above reaction are not fulfilled.

In the Héroult furnace the desired change takes place within the slag itself and is a result of its reducing nature, due to the presence of calcium carbide. Calcium carbide is used for the deoxidation of the bath and forms spontaneously in the furnace under the action of the electric arc.

The strongly reducing slag first deoxidizes the steel bath in such a way that the metallic oxides pass into the slag and are reduced to metal which returns into the steel bath, while the calcium carbide is oxidized to lime and carbon monoxide. After this reaction is completed (i. e., when the slag and the bath contain no longer any metallic oxides), the reducing slag acts on the metallic sulphides and changes them to calcium sulphide exactly according to equation (2) (with the only exception that calcium carbide acts as reducing agent instead of pure carbon). In this way the sulphur content can be reduced to any desired amount, if only sufficient time is allowed for the reaction.

It is not necessary to use pure lime, free from sulphur. If the lime contains sulphur in form of calcium sulphate, iron sulphide will first be formed according to (1) and the sulphur content of the bath will be increased. But this will not affect the end result. The practically complete removal of sulphur by reaction (2) does not depend on the quantity of sulphur present. The only conditions which must be fulfilled are a sufficient amount of lime and calcium carbide and freedom of the slag from metallic oxides; as long as oxides are in the slag, they will be preferably reduced, and only after deoxidation is complete, the sulphides will be reduced.

It was emphasized above that any oxidation of calcium sulphide to sulphate would make success impossible. In the Héroult furnace this oxidation is impossible for two reasons, one being the strongly reducing nature of the slag, and the other the fact that the Héroult furnace has a neutral atmosphere, which distinguishes it sharply from the open hearth with its oxidizing atmosphere.

It is now easy to sketch the process of desulphurization in the Héroult furnace. If the treatment begins with oxidizing smelting, the oxidation is accompanied by desulphurization in the same way as in the open-hearth furnace, but to a much greater extent, because the slag in the Héroult furnace is of high fluidity and therefore a good solvent. The sulphur passes into the slag in form of sulphides of iron or manganese.

During the following deoxidation period (with which the

electric-furnace treatment will begin in general) iron and manganese sulphides will pass into the slag as long as the latter contains oxides. But this will have no effect on the final result. The removal of sulphur during the deoxidation period really begins only when the slag no longer contains metallic oxides. Then calcium sulphide is formed by reaction (2), as described before.

Practical experience confirms these views. In the beginning of the treatment the removal of sulphur is quick, as a result of increasing temperature. Then follows a period during which the sulphur content remains practically constant until the slag gets free from metallic oxides. The slag then disintegrates to a white powder. Beginning from now on, the removal of sulphur is again rapid, until the final results, given above, are reached.

In this process two points are of special importance.

First, desulphurization in the Héroult process is not a separate operation, but accompanies the deoxidation. In the Héroult process it may, therefore, be said to be impossible to regain any appreciable amount of sulphur in a thoroughly deoxidized charge; and this is true whether the sulphur content of the raw material is high or low.

Secondly, the desulphurization in the Héroult process goes on without any effect on the chemical composition of the steel bath in other respects. This is of importance for various branches of the steel industry, but especially for foundry practice, if for special castings a low content of manganese or silicon is required. Cast iron of such composition contains often too much sulphur. For such purposes a low grade of pig iron, with small amounts of manganese or silicon, may be refined in the Héroult furnace; and it does not matter what the content of sulphur is. Dr. Geilenkirchen gives the results of two experiments made in this direction. The figures given in the following analyses under "S before" and "S after" are the sulphur percentages before and after treatment in the electric furnace:

C.	Mn.	Si.	P.	S before.	S after.
3.00	0.69	2.17	0.468	0.496	0.005
3.69	0.57	0.49	0.356	0.450	traces.

In the first case the percentage of carbon was reduced in the electric furnace by addition of scrap.

In conclusion Dr. Geilenkirchen acknowledges his indebtedness to Prof. Eichhoff, who has coöperated with him in the solution of these problems.

* * *

Prof. B. OSANN, in his essay based on experiments with the Roehling-Rodenhauser furnace, also emphasizes that the removal of sulphur in the electric furnace is essentially due to the formation of calcium sulphide. His experiments were made with molten soft steel of 0.1 per cent C.

In the first period of the treatment the phosphorus is removed. This may be successfully done by means of lime and roll scale (walsinter). Lime alone or lime and manganese ore do not give satisfactory results. The removal of phosphorus by oxidation requires evidently a substance giving off oxygen, in this case iron oxide.

Until the phosphorus is removed, it is therefore impossible to begin with carburization. Further, since removal of sulphur is possible only with a slag free from iron, desulphurization cannot start at an earlier moment. Carburization is carried out by charging retort coal in bags. Desulphurization requires a slag made from lime and fluorspar, with additions of ferro-silicon.

The refining process consists, therefore, of three steps: removal of phosphorus, carburization, and removal of sulphur. The latter two steps may start simultaneously.

Of the eight runs described by Prof. Osann the following two are reproduced in Table I because they represent normal operation (see page 407).

In the first period of the process, as shown in the tables, the phosphorus is reduced to the desired amount. The fact that after this first period the phosphorus slightly increases again is

due to the silicon addition. The old slag from the dephosphorization period had not been completely removed and the phosphoric acid in it was reduced by the silicon, so that phosphorus returned into the steel bath.

Concerning the reactions by which sulphur is removed, there was some uncertainty in the past. It was first tried to remove the sulphur by means of lime to which fluorspar was added to get a fluid slag. It was not known at that time that a slag practically free from iron was absolutely necessary. The successful removal of sulphur requires a slag of lime and fluorspar with additions of ferrosilicon.

As soon as the dephosphorization slag has been removed, ferrosilicon in large pieces (of egg size) is charged (together with the carbon for deoxidation). After a slag has been formed, the same ferrosilicon alloy, reduced to pea size, is thrown on the slag and this is repeated until the desired result is obtained.

The quantity of ferrosilicon charged in large pieces is so proportioned that the bath would contain about 0.5 per cent silicon if there were no losses. Only for steels, the silicon content of which must be low, less ferrosilicon is used. The author always used 50 per cent ferrosilicon. The ferrosilicon is first charged in large pieces because its action is intended to extend over a longer period.

The two charges 1 and 5, about which details are given above, represent normal methods of working for hard steel and soft steel respectively.

Other comparative charges, described by Prof. Osann, show that the sulphur is not removed if ferromanganese is substituted

RUN 1 (HARD STEEL)	C.	Mn.	Si.	P.	S.
After treatment with roll scale.....	0.105	0.204	0.016	0.012	0.069
Addition of 3 kg 50% ferrosilicon (egg size) and 15 kg coal. Slag made from 10 kg lime and 4 kg fluorspar. When slag was fluid, the composition of bath was.....	1.07	0.248	0.092	0.020	0.044
5 kg lime, 2 kg 50% ferrosilicon (pea size) and 2 kg fluorspar thrown on slag.....	1.07	0.234	0.096	0.013	0.028
Since the slag was still dark, another addition of 1 kg 50% ferrosilicon and 1 kg fluorspar was made. The color of the slag became lighter.....	1.07	0.463	0.19	0.015	0.016
Again 2 kg 50% ferrosilicon and 2 kg fluorspar added. The slag now white. Furnace tilted.....	1.05	0.263	0.25	0.016	0.008
Composition of the last slag: 28.66 SiO ₂ , 43.30 CaO, 2.59 FeO, 0.70 MnO, 0.45 S, iron 2.22.					
RUN 5 (SOFT STEEL)	C.	Mn.	Si.	P.	S.
Charged.....	0.139	0.435	0.014	0.053	0.053
After treatment with roll scale (15 kg) and lime, and removal of slag.....	0.109	0.406	0.016	0.026	0.053
Charged 6 kg 50% ferrosilicon (egg size) and slag made from 15 kg lime and 6 kg fluorspar. 10 kg of pea size ferrosilicon added.....	0.141	0.406	0.35	0.031	0.020
Some time later.....	0.127	0.406	0.34	0.031	0.016
Composition of last slag: 10.48 SiO ₂ , 63.70 CaO, 2.8 Al ₂ O ₃ , 5.44 MgO, P trace, 1.47 S, 0.77 FeO, 0.54 Fe ₂ O ₃ , 0.98 total iron, 0.09 total manganese.					

for ferrosilicon. The results are still more unsatisfactory if lime and fluorspar alone are used (or with some sand) without ferromanganese or ferrosilicon.

The analyses of the slags given for the different charges show clearly the relation between iron content of the slag and sulphur content of the bath. If the slag contains considerably more than 2 per cent of iron, the removal of the sulphur is unsatisfactory.

Prof. Osann concludes that an iron content in the slag prevents desulphurization of the steel bath, on account of the reaction $\text{FeO} + \text{CaS} = \text{FeS} + \text{CaO}$, which is a strongly exothermic reaction. He emphasizes the difference between removal of sulphur as manganese sulphide and as calcium sulphide. Sulphur is removed as manganese sulphide in the mixer. A content of ferrous oxide in the slag is not detrimental in this case (because the reaction $\text{FeO} + \text{MnS} = \text{FeS} + \text{MnO}$ evolves so little heat at ordinary temperature that it may be assumed to proceed in the opposite direction at higher temperature). A complete removal of sulphur is, however, impossible in this way. It requires the formation of calcium sulphide.

A substitute for lime has not yet been found. Alkali metals, which are preferably employed as carbonates (not as chlorides)

are effective, as experiments in Voelklingen have shown. But they are expensive and destroy the brickwork of the furnace.

The use of magnesia (which comes any way from the furnace walls into the slag) is not successful, nor the use of manganese oxide. A high content of manganese in the steel bath (up to 1 per cent) has no influence on the sulphur content below 0.05 per cent.

To reduce the iron oxides in the slag, only ferrosilicon has been found effective, besides carbon, which alone, however, is insufficient. The high oxidation heat of silicon manifests itself by inducing the reaction $2\text{FeO} + \text{Si} = 2\text{Fe} + \text{SiO}_2$ and producing a high temperature in the slag. Manganese is no efficient substitute, nor has calcium carbide been found effective in the induction furnace. The formation of calcium carbide (which is easily detected by the smell of acetylene when the white slag disintegrates or is wetted) must, therefore, be considered to be simply a secondary phenomenon. A high temperature helps the removal of the sulphur.

Prof. Osann finally remarks that possibly a gaseous compound, silicon sulphide, plays a part. This is not impossible, but has not yet been proven.*

* * *

Mr. JOH. HARDEN, writes in *London Engineering* of Aug. 14, with respect to Prof. Osann's paper, as follows:

"1. It has been found by experience that the metal bath should contain an excess of oxygen after the dephosphorization has taken place, in the first instance, in order to prevent the phosphorus wandering back into the metal again. But this is not the sole reason, as will be set forth below.

"2. It has been found that a good desulphurization and deoxidation was effected when calcium carbide was afterward found in the slag.

"3. Hence it was assumed that the carbide promoted this reaction. Ready-made carbide was, therefore, added to the bath in order to hasten the reaction, but it was found that this did not have the desired effect unless the temperature was raised to such an extent as to decompose the carbide, which may be effected in an arc-furnace (where 'good' results are said to have been obtained in this manner).

"4. A good desulphurization and deoxidation could, however, be obtained by adding carbon powder, or, still better, ferrosilicon to the bath.

"Conclusion.—Now, to my mind, the conclusion is this: To a bath of steel, containing sulphur and an excess of oxygen, we add calcium oxide. This will not, at this temperature, take up the sulphur; we also add, therefore, ferrosilicon, which is instantly attacked by the oxygen, thus raising the temperature (like aluminium and iron oxide in the thermit process). The temperature is increased chiefly on the surface under the slag blanket, and this increase of temperature in presence of the carbon at hand in the steel is sufficient to decompose the lime into free calcium and oxygen, which latter is also consumed by the highly combustible silicon. The calcium, again, having a great affinity to sulphur at this temperature, will act as a strong desulphurizer, instantly forming calcium sulphide, which may be found in the slag. A smaller part of the calcium, however, will also combine with the carbon present, forming calcium carbide.

"Consequently, the carbide is not acting per se as a desulphurizer, but its formation is only an indicator that the necessary reaction has taken place. The real desulphurizer is the free calcium, which is liberated by the combustion of the silicon, by which reaction the oxygen in the steel is consumed. Hence the necessity of an excess of oxygen in the bath in order to obtain a good desulphurization.

"A further consequence is that the presence of a large amount

*In this connection it is interesting to refer to the following note of Mr. Max Ilaff (our March issue, p. 96): "I have found considerable reaction on heating sulphur and silicones together. When iron containing a high content of sulphur and silicon, is heated to the high temperature existing in electric furnaces, the silicon and sulphur react. Gaseous (at that temperature) silicon sulphide is evolved. It can be easily caught and identified as such or can be absorbed by having calcium silicide in contact with the electrically heated iron. This calcium silicide, when cold, liberates sulphuretted hydrogen in contact with water."—Ed.

of carbide in the slag shows that a waste of power and heat has taken place; there should be only sufficient carbide present to indicate that the reaction has taken place. The formation of carbide is always an expensive affair, and the presence of a large amount would in this case be useless.

"If it is as stated, we also understand why an addition of ready-made carbide is of no use unless, for instance, in an arc furnace. Here, again, the carbide must be decomposed, giving free calcium for the formation of calcium sulphide, but it is obvious that such a reaction must be more costly, especially where power is expensive; then both the ready-made carbide and the ferrosilicon must be made by expenditure of power and it seems to be a waste to again spend power to decompose the former while the latter is more heat-giving in itself.

"This also explains why it is better to add ferrosilicon than carbon, although the latter can be used. If so, however, we need more power, as the reaction of ferrosilicon is in itself more heat-giving than the carbon.

"To my mind this seems to be the course of reaction in the electric furnace, but the theory may perhaps also be applied to other processes, such as the Thomas and open-hearth process."

Electrolytic Refining of Gold, Silver and Copper at the United States Mint, San Francisco, Cal.

By ROBT. L. WHITEHEAD.

(Concluded from page 359.)

The **melting room** equipment, shown in Fig. 13, consists of four melting furnaces for No. 80-100 black-lead crucibles and one reverberatory water-jacketed furnace. The hearth is 6 ft. by 3 ft. and is made of magnesite firebrick. This furnace is used for copper melting and the cupellation of base bullion. A small melting furnace and a muffle for assaying are also provided.

The whole equipment in this room is operated with California crude oil and gives entire satisfaction as to efficiency and cost. It was furnished by the Rockwell Furnace Company, New York, who were the first people to introduce fuel-oil melting into the government mints and up to the present time are the only ones who have built a successful furnace for mint work. The complete melting and annealing equipment for the Denver mint was furnished by the same firm and operated with Colorado crude oil.

The furnace design at San Francisco differs from those of the Denver equipment. Being an open-top furnace, with a circular combination chamber, it is much easier repaired and consumes much less oil, the consumption being less than 4 gal. per hour per burner. The oil is heavy and has an asphaltum base and flows very slowly, but has a greater number of heat units than Eastern oils. With seven furnaces in operation, seven hours per day, the total cost per month does not exceed \$60. This is a remarkably low expense for fuel for the metal operated on, about 600,000 oz. being melted during the month.

The system of flues and dust chambers has not been overlooked. The values which pass off during melting, pass through an individual chamber, 3 ft. x 4 ft. x 5 ft. From this chamber the gases pass through two main settling chambers, 18 ft. x 3 ft. x 5 ft., one above the other. The flues have partitions of checker work which retard the flow of the gases, causing greater condensation before they enter a flue 40 ft. long, 3 ft. wide and 3 ft. high. This latter flue opens into a settling chamber, 21 ft. x 15 ft. x 6 ft.

This chamber is built around the stack so that the outlet is on the opposite side to the entrance, thus compelling the gases to make a complete circuit of the chamber before escaping to

the air. The flues and chamber are in the attic above the melting room. There is also located here the 2000-gal. tank which supplies the two Rockwell oil pumps, only one of which is operated at a time. The main storage tank of 10,000-gal. capacity is located in the street adjoining the mint building, a steam pump being used to force the oil into the attic tank. The Sturtevant blower No. 4, located in the attic, supplies about 700 cu. ft. of air per minute to each burner at a pressure of 11 oz.

The weighing room or office of the foreman is conveniently located for handling the metals to and from the vault, which is situated in the rolling room adjoining the office.

The equipment for this room consists of one Troemner No. 5 bullion balance, weighing 6000 oz in each pan. It is sensitive to 1/100 of an oz. There is also one 3-ft. balance for weighing small bars.

A system of accounts was inaugurated in the refinery, which is a new departure, in that it enables the foreman to keep in touch with the operations in a more intelligent way.

All bullion to be refined is weighed out in melts in the melter's and refiner's office, and again weighed by the foreman on his own scales, and when any discrepancy exists, it is adjusted before receiving for it. All fine bars are first weighed by him, before being delivered, and if correct in weight, a receipt is received from the melter and refiner.

A complete refinery account is kept by the assistant foreman, computations of receipts and deliveries being carefully made and checked with the melter and refiner's office, before entering into the refinery books. As the two accounts are compared from time to time there is no chance of error.

The system has this further advantage that the foreman can tell from time to time just how he stands as to the accumulation of metal in the process, and can keep his odds and ends worked up close. The government refineries do not work as close as outside plants, possibly because there are no interest charges on the values tied up. But this is really no excuse, for the metal is never as safe in the refinery as in the melter and refiner's



FIG. 13.—MELTING ROOM.

vault. It is very hard to start anything new in the government service, as it always meets with opposition, and very frequently from sources one least expects. Of course, we always look for it from the average workman.

The rolling room, which is the last of the rooms at present equipped, has an acid-proof stone floor. The slabs are 30 in. x 30 in. x 1½ in. in dimensions. In the middle of this room is a 10 x 8 water-cooled rolling mill driven by a 15-hp Westinghouse 230-volt, direct-current motor.

The mill is used for rolling cathode sheets of fine gold; the ingots to be rolled are $\frac{1}{2}$ in. thick, $3\frac{3}{4}$ in. wide and 14 in. long and when finished are about 60 ft. long, $\frac{1}{8}$ in. wide and $\frac{1}{100}$ in. in thickness. By means of a special guide, designed at the Denver mint, the ingots are rolled out to this length without cutting. The guide contains 12 steel rollers, six on a side, set vertically. The object of the rolls in the guide is to prevent the buckling of the long strips in passing through the rolls, which trouble increases as the strips get thinner. By having the strip in one

be different. As few plants have as much as 50 parts per thousand in gold, it would fall off as a mud and would work through the bag. Besides the propeller system of circulation causes too much agitation in the tank.

The deposit is coherent only in a way. The cathodes have to be taken out each day and scraped to knock off the trees which form, to prevent short-circuiting. Further, over 10 per cent of the deposit falls to the bottom of the tank.

The great drawback to the process from a commercial standpoint is the low current density required to obtain this coherent deposit (from 7 to 8 amp per square foot of cathode surface on the start and toward the end from 4 to 5), thus tying up the silver and gold in the tanks about eight days.

The only feature which would be attractive is the low voltage per tank, as compared to the Thum process, namely, 1 volt as compared to $3\frac{1}{2}$.

The coherent deposit is obtained by the use of gelatine, the idea having originated with Anson G. Betts in electrolytic lead deposition, where he uses glue.

The silver deposit that falls to the bottom of the tank in one of the mints is melted and run through the Thum process, while in another mint it is used together with the daily scrapings

from the cathodes to convert it into silver nitrate in replenishing the electrolyte in silver. Just how much is used for this purpose is not known. The anode residue of gold, which is solid and resembles chocolate in color, generally has a core of silver running through it, and has to be boiled first in nitric and finished in sulphuric acid. This is done so as to get an anode sufficiently low in silver for the Wohlwill process, as all gold from the silver tanks has a second electrolytic separation.

The purification of the electrolyte in this process is a very important adjunct. As the anodes generally contain 10 per cent lead, bismuth, copper and zinc, a large volume has to be removed each day. The silver is precipitated with salt. The filtrate containing the copper is run into the sewer. It has been considered necessary at one of the mints to heat the electrolyte and carry 5 per cent of free nitric acid in solution. This appears absurd to me, and accounts for the large amount of acid used at this institution as it decomposes and fills the atmosphere of the room with nitric acid fumes.

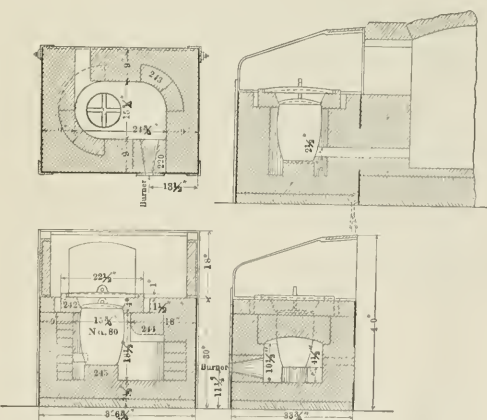


FIG. 15.—CRUCIBLE MELTING FURNACE.

The reason given for it is that the anodes work out more uniformly and will stand a higher percentage of gold. It is claimed the anodes contain 300 parts gold per 1000. Whether the

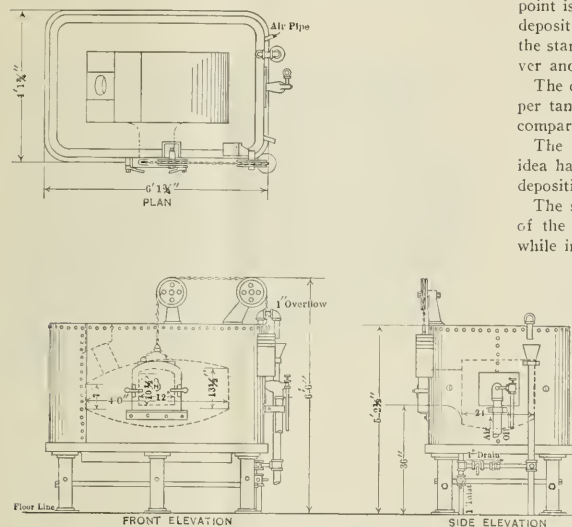


FIG. 14.—WATER-JACKETED COPPER FURNACE.

continuous piece, very little scrap is made in cutting cathodes, which are about 10 in. long. About 300 cathodes are used every 24 hours. The cutting machine is operated by a $\frac{3}{4}$ -hp motor, with an adjustable bed for any length of cathode, can easily be operated by one man. The rolling, annealing and cutting of cathodes is done in this room in about two hours' time.

A 150-ton hydraulic press operated by a 5-hp motor is located in the extreme end of the room. At present there is little use for it except to press such material as cement copper, slimes or other finely divided material before melting.

In connection with the layout of the rooms which constitute the refinery, are dressing and toilet rooms. The dressing rooms have steel sanitary lockers. The toilet and shower baths are finished with the same kind of stone as the floors, the whole room having a decided sanitary appearance.

A comparison of the methods used by the mints will be interesting to the readers of this paper, in ascertaining to what extent the methods are valuable from a commercial standpoint.

The method of silver refining in use at San Francisco is well known to the commercial world, being the Thum process with certain modifications, for instance, with respect to circulation of the electrolyte. This entails a larger volume of solution, but enables one to purify it to a better advantage, especially when working anodes with from 5 to 10 per cent of base. I will not go into detail about this process, but will refer to that used by the other mints, which is generally known as the vertical or Tuttle process.

With this process installed in any establishment it is necessary to have a rolling mill for making the silver cathodes. The anodes and cathodes are about 3 in. apart. The anodes are bagged individually. As the composition of the anodes contains $\frac{1}{3}$ in a thousand in gold, the gold remains intact and there is very little weight on the bag. In outside plants it would

conditions warrant the large consumption of acid and the foul atmosphere resulting from it is a question.

In a former article on the Denver mint equipment I suggested certain features of the Wohlwill gold process which might interest the commercial plants. I am not surprised that they have not tried it after going through the government plants, where they see so much gold tied up in the process, naturally concluding that it is necessary. The electrode bars are covered with strips of fine gold, the hangers are the same, also a large stock of gold chloride is always on hand, as well as a goodly stock of anodes and cathodes.

In an industrial plant this can be made vastly different, viz., the electrodes can be covered with strips of fine silver, also the hangers can be made of the same material. More attention will be required as regards contacts. I would not advocate immersing the hangers into the bath, as that would give a much poorer contact and only save very little scrap.

In regard to cathodes, I would use rolled fine silver and strip them, only presenting one side for deposit, one line of anodes and two lines of cathodes. This can easily be done, as I have made proof gold by stripping the deposit from a strip of gold 998.5 in fineness, this, of course, with the deposit only on one side. It would be necessary, though, to have several tanks for this purpose, using a current density of 150 amp per square foot of cathode surface. Eighty-five per cent of the gold could be refined in 24 hours, the remaining 15 per cent in 48 hours.

The gold constantly tied up would be the amount in the electrolyte, which would vary with the production of the plant. As all fine bars from industrial works that reach the mints with few exceptions contain platinum in small quantities, this metal would be saved and to some extent offset the interest charges. When one considers that the government refineries are saving yearly about \$50,000 worth of platinum with very little expense and for which nothing is paid, it is about time some experimenting on the part of the industrial plants was under way to test the matter fully from a commercial point of view.

The use of silver cathodes would in all probability lower the fineness of the deposit by a half point. However, there is no advantage for an industrial plant in depositing gold as fine as the mint gold, 999.5. They would get no more for it and only save a little silver.

In most outside plants it is necessary to nitre the melted gold to remove lead, bismuth and tellurium, and sometimes selenium. Otherwise it would be brittle and be subjected to a toughening charge at the mints. This process is costly and entails a loss. By the electrolytic process these metals are all removed and the cathodes, as soon as melted, are poured into bars, thereby reducing the melting loss to a minimum.

It would only be necessary for the plants to boil their gold mud sufficiently to make anodes from 850 to 900 fine. At San Francisco no boiling was required; only thorough washing was necessary. As this was done in a centrifugal, the gold mud could be washed free of nitrate of silver.

Having worked the sulphuric acid process of refining silver and gold for a number of years, and electrolytic gold refining for the past four years in the government mints, I believe that outside plants, with their progressive and hustling spirit, would soon make the Wohlwill process of gold refining a commercial success.

Steel Hardening Furnace.

At the last general meeting of the German Association of Electrical Engineers Mr. C. R. STRAUBE presented a paper giving further details on the electric hardening and annealing furnace with fused electrolyte, which was described before in papers of L. M. Cohn, noticed in our Vol. 4, page 367, and Vol. 5, page 428. A furnace of this type (which is controlled by the Allg. Elek. Ges., of Berlin, and the General Electric Company, of this country) was shown in the exhibit of Mr. C. J. Russell at the last Philadelphia meeting of the American

Electrochemical Society, as noticed in our Vol. 5, page 233.

Mr. Straube's paper, which may be found in full in *Electrotechnische Zeitschrift* of Aug. 6, begins with a tribute to the research work of Mr. W. Taylor on high-speed steels. In their manufacture the method of hardening is of prime importance. The steel articles to be hardened must be heated to an exactly defined temperature which varies with the nature of the steel. For carbon steels the required temperature is between 700 and 900° C., for ternary or quaternary steels it is higher, for instance, above 1100° C. with Taylor-White steel containing 18 per cent W, 5.5 Cr, 1.0 C, 0.15 Mn. Modern high-speed tool steels, i. e., chromium-tungsten steels, must be hardened at 1300 to 1350° C. This temperature is near the melting point.

Evidently it must be possible to produce temperatures between 700 and 1350° C. in a hardening furnace. To be successful it is further necessary that the heating takes place quickly, and that the temperature can be adjusted, so that the difference from the desired temperature is certainly less than 30°. Further, the heating must take place in the absence of oxygen and of fuel gases. Finally one of the most important requirements is that the temperature be uniform within the furnace.

In a muffle furnace the temperature in the center is lower than near the walls. This fact caused a peculiar error in a factory which formerly used muffle furnaces and then introduced the electric furnace described below. In the muffle furnace the temperature for hardening different kinds of steels had been carefully determined in the central zone of the furnace. When the same temperature was then produced in the electric furnace it was found to be not sufficient for hardening. The reason was that the former temperature determinations in the muffle furnace had been made in the center, while the steel parts to be hardened (teeth, edges, etc.) were near the walls. Since near the walls of the furnace the temperature was higher than that measured in the center of the furnace, the measured temperature did not give the correct hardening temperature. For the electric furnace with its absolutely uniform temperature, a higher temperature had, therefore, to be employed than existed in the center of the muffle furnace.

The electric furnace for hardening steel consists essentially of a firebrick crucible, two opposite sides of which contain iron electrodes very low in carbon; the melting point of such iron is 1500 or 1600° C.; that is, higher than that of any steel. The crucible is surrounded by a dense layer of asbestos, which is again embedded in a layer of refractory material which is a non-conductor of heat, the whole being held together in a steel box. After 10 hours' operation of the furnace at 1350° C. it is possible to touch the iron walls with the hands without any danger. Heat conduction is, therefore, reduced to a minimum.

The connections to the low-carbon steel electrodes are also made of soft steel, and these are connected to the secondary copper bars of the regulating transformer. This transformer reduces the primary voltage (110 to 550 volts, single-phase) to 5 to 70 volts.

Fig. 1 shows the hardening equipment of a modern high-speed tool factory. The electric furnace is in the center. At the right the regulating transformer and controller are seen, while the quenching tank is at the left. The proximity of the latter to the furnace is perhaps the most interesting feature of the picture. Various pipes lead to the cooling tank to supply steam or cold water to pipes within the tank, so as to regulate the temperature in the tank at will.

The crucible of the furnace is filled with a molten electrolyte and the article to be hardened is simply placed within the fused salt bath. According to the steel to be treated, the nature of the fused salt is chosen. The intention is to use a salt with a melting point very near to, but below, the eutectic temperature of the steel. Potassium chloride, with a melting point of 775° C. is used, for instance, with carbon steels. Barium chloride, with a melting point of 950° C., is used for high-speed tool steels, and mixtures of bath salts are used for mean temperatures. For temperatures between 200 and 400° C. potassium and

sodium nitrate may be used; for temperatures between 1300 and 1600° C. fluorspar and magnesium fluoride.

To fuse the solid salt, which is fed into the furnace, an auxiliary electrode is employed which is connected by a cable with one of the two electrodes of the furnace. A piece of arc-lamp carbon is placed between this auxiliary electrode and the other electrode of the furnace. The salt around the arc-lamp carbon is first fused and by moving the auxiliary electrode gradually further away it is easy to bring the whole bath into a state of fusion. During fusion of the salt a higher e.m.f. is required on account of the greater resistance.

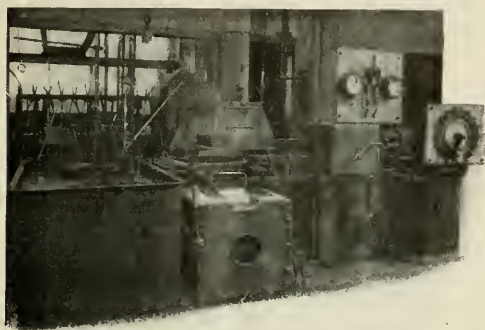


FIG. 1.—ELECTRIC HARDENING FURNACE IN TOOL STEEL WORKS.

Regulation of the temperature is accomplished by the regulating transformer, by means of which certain numbers of primary windings can be switched on or off. By further varying the nature of the salt it is easy to adjust the temperature exactly. Electrolytic effects of the alternating current are hardly noticeable at a frequency of 25, while they are practically absent with a frequency of 50 periods.

The latest improvement of this furnace is the possibility to connect it to a three-phase system. For this purpose the three-phase currents are changed within the regulating transformer by means of the well-known Scott method into two-phase currents, and the latter are supplied to the bath through four electrodes. The two pairs of two electrodes are placed alongside the four sides of the furnace so that the furnace represents

one phase only of the secondary two-phase system is loaded. Fusion is obtained in the same way as with the single-phase furnace described above, but the auxiliary electrode is not carried over to the other electrode of the same phase, but to one electrode of the other phase, and in this way it is accomplished that the system remains unbalanced for 5 or 10 minutes only.

The heating of the steel articles within the fused bath takes place, of course, in the absence of oxygen. Moreover, when the steel articles are taken out of the bath, there remains on the surface a thin adherent layer of salt which prevents any oxidation by the air. Only when the articles are placed within the quenching tank, this layer of salt cracks off.

In the old lead-bath or salt-bath furnace heated from the outside, the temperature of the bath decreased whenever a steel article was introduced, and it took some time to bring the temperature again to the desired degree. On the other hand, in the electric furnace when a steel article is introduced the level of the bath rises and the cross-section is thereby increased so that more current flows through the bath and the decrease of temperature due to the introduction of the steel article is thereby automatically compensated by the increase of Joulean heat.

It is easy in the electric furnace to adjust the required temperature within 10° C., and the temperature is practically constant in all parts of the crucible. Fig. 2 shows the measurement of the temperature by means of the pyrometer P.

The iron tube, bent at a right angle, contains at the lower end of its vertical arm the joint of a platinum, platinum-rhodium element, within various protective covers. The two terminals at the outside end of the horizontal arm are connected by two wires to a galvanometer, on which temperatures up to 1600° C. can be read directly.

A special protecting muffle is placed on those parts of the pyrometer tube along which the changes of level of the bath take place. The pyrometer tube itself is thus protected against any deterioration from change of level. *d* in Fig. 2 represents the change of level.

A layer of about 10 mm thickness below the surface of the bath is by 10 to 20° colder than the balance of the bath. With this exception the temperature is practically uniform throughout the bath. No greater differences of temperature than 3° C. have been found.

Cost of Electrolytic Hypochlorite.

As noticed before electrolytic hypochlorite is used as disinfectant in the Metropolitan Borough of Poplar in England. From last year's report of the medical officer, Dr. F. W. Alexander, noticed in our English contemporaries, we took the following figures on cost of operation:

Condition of Plant.—The wear and tear has been practically nothing to speak about. The plant after two years is still in good working order, turning out 185 gal. of solution in eight hours at an average strength of 4.5 to 5.0 gr. of chlorine per litre. It has not been necessary to renew any of the zinc electrodes, which, from their present condition, no doubt, can be used for a much further period. To prevent the salt from acting upon the iron, the interior of the large supply tank has been coated over with "rosbonite," a preparation which answers admirably. The saturators have been treated in a like manner. There has been introduced a very simple arrangement to insure the mixing of the preservative (hydroxide of magnesia) and a large amount of labor is also saved.

Cost of Plant, Etc.—Total cost up to date, January 31, 1908, of depot, plant, fittings, alterations, painting, testing, apparatus, carboys, syphons, etc., \$2,955.66. Initial outlay, 1906, was \$2,841.42, which shows that \$114.24 has been expended during the years 1906 and 1907 for carboys, sundry additional apparatus, repairs to depot, new electric light, paint, "rosbonite" and minor details.

Output.—The electrolytic disinfecting fluid manufactured from February, 1906, to January 31, 1908, a period of two years.

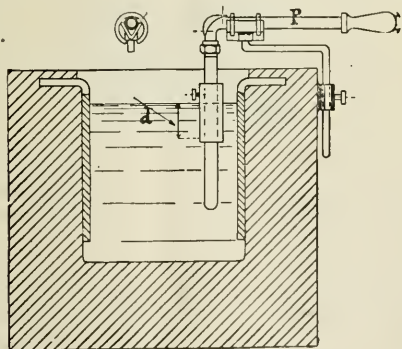


FIG. 2.—METHOD OF TEMPERATURE MEASUREMENT.

really a combination of two single-phase furnaces. The temperature within the furnace can be made practically constant throughout the bath. While the salt is brought to fusion, the three-phase system becomes unbalanced, since in the beginning

amounted to 32,586 gal., of an average strength of 4.5 gr. to 5.0 gr. of chlorine per litre (4.5 to 5.0 per 1,000). There was supplied, at a charge of 2 cents per gallon, to the works department (for watering roads, flushing gullies, sewer manholes and market places), 13,656 gal.; gratis to Guardians' institutions, October, 1906, to January 31, 1908, 13,800 gal.; gratis to managers of sick asylums, 6.42 gal.; and distributed to the public from the Council's four depots (including fluid supplied to Poplar and Bow Baths), 16,908 gal.; total, 32,586 gal.

Cost of Manufacturing.—The cost of electricity and materials in the manufacture of the 32,586 gal. of disinfecting fluid from February, 1906, to January 31, 1908 (a period of two years), was: Electricity (4,888 kw-hours at 3 cents per kw-hour), \$148.78; salt (at \$5.84, \$6.32 and \$7.79 per ton), \$44.80; chloride of magnesium (at \$18.87 and \$21.91 per ton), \$70.49; caustic soda (\$1.74 per 48 lb.), \$34.74; water, \$7.55; total, \$306. Corks, paraffin wax, labels and bottles cost, from February, 1906, to December, 1906, \$623.15; and from January 31, 1907, to January 31, 1908, \$111.44, while for the same two periods the testing reagents accounted for \$11.69 and \$13.64 respectively.

If carbolic acid disinfectants had been issued in place of electrolytic fluid for the period of two years from February, 1906, to January 31, 1908, based upon the expenditure of 1905, the amount expended would have been almost \$10,000, while the actual cost of electrolytic fluid for this period was less than \$5,000. This is a saving of about \$5,000 in two years, no consideration being taken of the 13,656 gal. supplied to the works department for watering roads, etc. Each cart for conveying away sludge from the street gullies is furnished with a 4-gal. jar of fluid, and instead of dusting around the gullies carbolic powder, there is sprinkled electrolytic fluid by means of a small ordinary watering can.

Since the initial outlay of building depot, plant and appliances was \$2,841.42, and repairs to depot, etc., during the years 1906-7 have amounted to \$114.24, making a total of \$2,955.66, the initial expenditure has not only been saved, but also a sum of about \$2,000. Also the rent of the manufacturing depot, \$150 per annum, is no loss to the borough, as the amount is paid into the electricity department's account.

The Direct Production of Copper Tubes, Sheets and Wire.*

By SHERARD O. COWPER-COLES.

The numerous processes involved in the production of suitable pure copper and its subsequent conversion into copper sheets, tubes and wire, by a series of operations, such as rolling, drawing and annealing, would occupy too much time to be referred to even briefly. The author has limited the paper to the direct production of copper tubes, sheets and wire by electrolysis from impure copper.

The methods described are all based on the work of Davy and Faraday's well-known fundamental law on electrolysis. If a pure copper electrode is connected to the positive pole of an electric circuit and placed in the solution of a pure copper salt, a weight of copper will be deposited upon the cathode connected to the negative pole, equal to the amount dissolved from the anode.

If the anode is of impure metal many difficulties are introduced, and if the current density is increased sufficiently to enable the metal to be deposited at such a rate as will give commercial results, other serious difficulties arise. Electrometallurgists have been working for 30 years or more devising methods to overcome the difficulties experienced in applying Faraday's law to the commercial production of copper tubes, sheet and wire from comparatively impure copper, so as to get the physical properties of wrought copper, while depositing at a sufficiently rapid rate.

The refining of copper by electrolysis has now assumed vast

proportions, and the annual output of electrolytic copper in the year 1907 has been estimated at 400,000 tons, equal to 56 per cent of the world's production, and the capital invested in the industry at about \$75,000,000. The whole of the copper thus produced is in the form of rough slabs or cathode plates which have to be smelted and worked to the desired forms.

Electrometallurgists have been striving for many years to devise a process which does away with the smelting of copper after it has been electrolytically refined, and to electrodeposit copper at the end of the refining operation in such a form that it can be placed direct on the market as finished sheets, tubes and wire.

Wilde's Process.—It was observed shortly after Elkington practically applied Faraday's law to the refining of copper in the year 1865, that the current density (hence simultaneously the

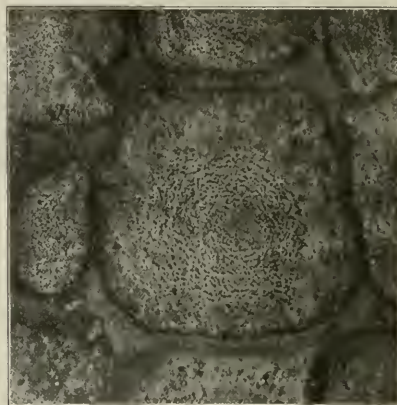


FIG. 1.—CATHODE SURFACE, LEAD COATED WITH COPPER, SHOWING EFFECT OF IMPINGEMENTS OF JETS OF ELECTROLYTE.

rate at which the copper is deposited) could be considerably increased by circulating the electrolyte or moving the electrodes. It was soon found that circulating the electrolyte alone was unsatisfactory, and that the best results could be obtained with a vertical mandrel revolved in the electrolyte. Wilde was one of the first to use a cylindrical cathode, his object being to deposit

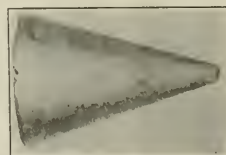


FIG. 2.—COPPER CONE TO DETERMINE CRITICAL SPEED.

copper on iron rollers suitable for textile printing purposes, for which he took out a patent in the year 1875. The anodes consisted of copper cylindrical tubes, and the iron cylinder to be coated with copper (the cathode) was placed in the center of the cylindrical vat and caused to rotate on its axis. Such an arrangement, in conjunction with a circulating propeller placed in the electrolyte, ensured an even distribution of copper over the whole of the surface uniformly along the length of the roller by means of the motion imparted to the solution, and the equal density thus maintained. The current density was low, considerably under 20 amp per square foot.

Elmore's Process.—The next development of importance was the Elmore process, which consists of using horizontal mandrels on which copper sheets or tubes are deposited, while agate

*A paper presented at the Bristol meeting of the (British) Institution of Mechanical Engineers, July 26, 1908.

burnishers travel continuously over the copper so as to consolidate it, and at the same time prevent the growth of copper trees or nodules. Even with the use of a burnisher, the current density could not be increased beyond 30 amp per square foot, and the mechanical difficulties introduced by the burnisher are considerable. Large works were erected to operate this process near Leeds and in Continental Europe, and are principally engaged in the production of large tubes and cylinders for special purposes.

Dumoulin's Process.—Dumoulin introduced, at a latter date, a process for burnishing copper during deposition with sheepskin as a substitute for agate, and claimed that the process had also

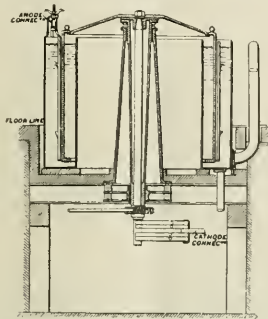


FIG. 3.—VAT USED FOR CENTRIFUGAL PROCESS.

the advantage of insulating any projections that might be formed on the deposited metal, the sheepskin impregnator coating all projecting parts within a thin film of animal fat, thus preventing further deposition until the surrounding depressions are raised to the common level. It was also claimed for this purpose that a current density of from 30 amp to 40 amp per

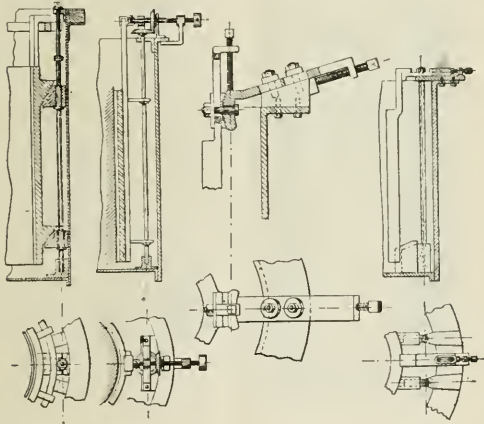


FIG. 4. FIG. 5.—ECCENTRIC AND SCREW WEDGE. FIG. 6.—UNIVERSAL. FIG. 7.—SLIDE AND WEDGE.

square foot of cathode surface could be employed at a voltage of about 1.6 per. vat. This process was tried on a large scale in England, but was soon abandoned.

Other Processes.—Attempts have been made at various times to further increase the rate of deposit by Swan, Elmore, Thofehn, Graham, Poore and others, by impinging jets of the electrolyte against the cathode surface. The quality of the copper is liable to vary in density if impinging jets alone are employed; it is, therefore, necessary to move the cathode, otherwise the

copper is deposited in the form of annular rings of varying density and smoothness, as shown in Fig. 1, which is a photomicrograph of a lead plate coated with copper by an impingement process at a current density of 160 amp per square foot (9.29 cm²), temperature 50° C.; the electrolyte being forced

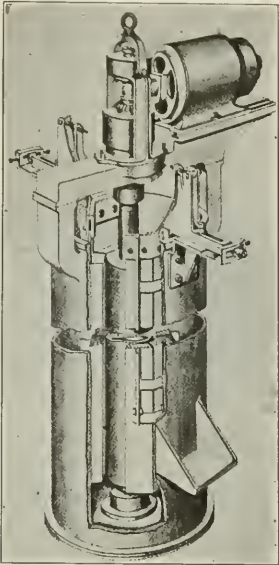


FIG. 8.—APPARATUS FOR DEPOSITING COPPER ON IRON ROLLS.

at a pressure of a few pounds through a lead box perforated with 1/4-in. (0.32 cm) holes at a distance of 1 in. (2.5 cm) apart from center to center.

The author when carrying out some experiments on the production of copper tubes and sheets by electro-deposition on

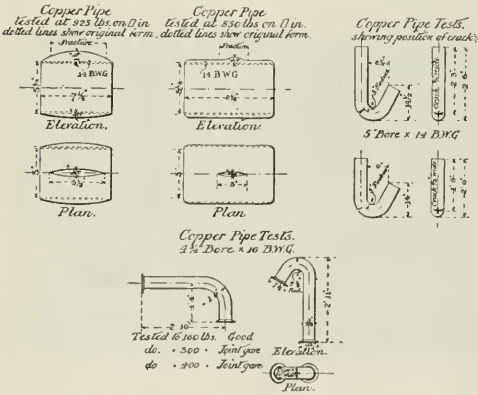


FIG. 9.—MECHANICAL TESTS ON COPPER PIPE MADE BY THE CENTRIFUGAL PROCESS.

rotating cathodes, observed that when the speed was greatly increased, entirely new results were obtained, and that a current density of 200 amp or more per square foot could be employed, the copper remaining smooth and having a tensile strength equal to the best rolled or drawn copper, and in some cases a tensile strength some 50 per cent higher than that obtained by the

ordinary process of casting and rolling, the tensile strength increasing with the rate of rotation of the mandrel. The result of revolving a mandrel at a comparatively high speed is that every molecule, as it is deposited, is burnished or rubbed down so as to produce a tough, fibrous copper, the usual order of things being reversed, the present practice being to put the mechanical work into a mass of copper by rolling or drawing instead of treating each molecule separately.

Centrifugal Process.—This observation led to further experiments, which resulted in evolving the process now known as the centrifugal copper process for the manufacture of sheets, tubes and wire, which will now be described in detail, together with the result obtained.

After a long series of experiments had been made to deter-

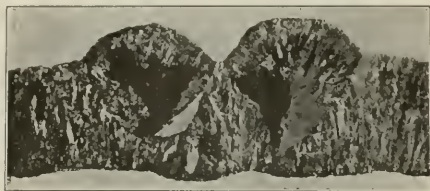


FIG. 10.—RADIAL CRYSTALLINE STRUCTURE OF COPPER NODULES.

mine the best composition for the electrolyte and the most economical current density to employ, the critical speed was accurately determined by means of revolving cathodes in the form of cones, Fig. 2. By observing the point at which the copper remains smooth, and by measuring the circumference of the cone at that point and multiplying it by the number of rotations per minute, the critical speed is readily determined; 200 amp per square foot is found to be the most economical current density, although a current density up to 500 amp per square foot can be employed by increasing the rate of rotation, but the increased cost due to increased voltage renders such a current impracticable for ordinary commercial work.

One of the chief difficulties inherent in any electrolytic or wet process for the production of copper tubes and sheets is having any working parts, such as bearings, in an acid copper sulphate

is immersed in the electrolyte. The cathode consists of a steel or cast-iron cylinder closed at one end, to which is attached on the inside a steel rod projecting below the edge of the mandrel to guide it into position; the cylinder can be 5 ft. or 6 ft. in diameter, or even larger, so as to produce a copper sheet of, say, 20 ft. long by 4 ft. or 5 ft. broad. Anodes composed of crude copper are placed around the mandrel with intervening spaces and are fed forward by suitable mechanical means, Figs. 4 to 7, as the copper dissolves away so as to keep the voltage constant.

One great advantage of the centrifugal process is that a very low voltage is required even when employing a very high current density; for instance, only 0.8 of a volt is required at the terminals of the vat when working at a current density of 200 amp per square foot of cathode surface. The effect of revolving the cathode is five-fold: firstly, it keeps the electrolyte agitated, so that there is always a fresh supply of copper ions in proximity to the cathode; secondly, each molecule of copper as it is deposited on the cathode is burnished or rubbed down by



FIG. 12.—COPPER TREES. EFFECT OF FREE ACID ON NODULE FORMATION.

(The three samples in the upper diagram and the two in the lower one relate respectively to no free acid, 2 oz. H_2SO_4 to gal.; 6 oz. H_2SO_4 to gal.; 8 oz., etc.; 10 oz., etc.)

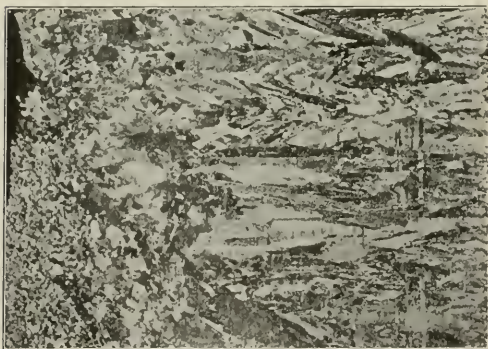


FIG. 11.—CRYSTALLINE STRUCTURE OF DEPOSITED COPPER.

solution, and this was one of the first troubles encountered when working the centrifugal process on a commercial scale. This difficulty was eventually overcome by constructing vats in the form of an annular ring, as shown in Fig. 3. It will be observed that by such an arrangement all working parts are outside the vat and do not come into contact with the electrolyte, so that the bearings can be lubricated in the ordinary way; only the actual face of the mandrel on which the copper is to be deposited

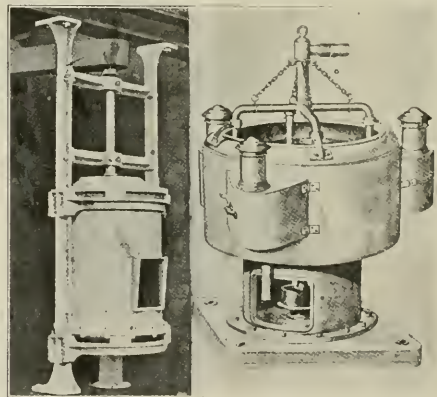


FIG. 13.—ATOMISER.

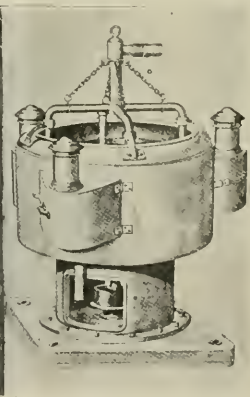


FIG. 14.—FILTER.

means of the skin friction between the revolving cathode and the electrolyte; thirdly, the rotation prevents any foreign matter that may be in suspension in the electrolyte settling on the cathode and becoming entangled by further copper being deposited around or over it; fourthly, it brushes away any air bubbles on the cathode, which are the cause of nodules forming, and, fifthly, the rotation of the cathode ensures the thickness of copper being uniform even when a mandrel of, say, 8 ft. in length is employed.

The method of making tubes by the centrifugal process is as follows: A mandrel somewhat smaller than the finished internal

diameter of the tube is prepared by coating it with an adhesive coating of copper by first depositing copper upon the surface from an alkaline solution and then thickening it up in an acid solution, the surface being highly burnished and treated chemically to ensure the easy removal of the deposited tube.

The mandrel thus prepared is then placed in a vat, as shown in Fig. 3 or Fig. 8, according to the diameter of the tube and its length. When the desired thickness has been obtained the mandrel is removed and placed in a horizontal or vertical lathe, and a round-faced roller run over the surface so as slightly to expand the deposited copper, which can then be readily drawn off.

Copper sheets are prepared in a similar manner, the only difference being that the mandrels are of much larger diameter

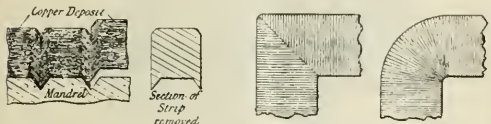


FIG. 15.—FORMING WEAK LINE OF CLEAVAGE DUE TO CRYSTALLINE STRUCTURE.

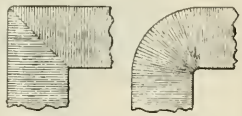


FIG. 16.—EFFECT OF SHARP ROUNDED CORNERS ON CRYSTALLINE STRUCTURE OF METAL CASTINGS.

and a narrow insulating strip is fitted down one side so that the sheet can be easily removed by inserting a tool under one of the edges of the deposited copper. It is no more costly by the centrifugal process to make thin sheets than thick ones; copper foil can be made in five minutes direct from crude copper.

Copper tubes produced by this process without any drawing have given a maximum stress of 17 tons, and tubes after drawing have withstood a pressure of 3000 lb. per square inch without showing any signs of distress, as shown by the following test made by Mr. David Kirkaldy:

Diameter outside, inches.	Thickness of metal (mean), inch.	Length, inches.	Weight per foot, lb.	Subjected to a pressure, lb. per sq. in.
1.123	0.063	4.94	0.814	3,000

Sheets made without any rolling have given a maximum stress of 28 to 30 tons and more per square inch according to the peripheral speed at which the mandrels were revolved. The following are some tests made by Mr. W. Harry Stanger:

Dimensions, in.	Area, sq. in.	Reduction of area at fracture, per cent.	Extension on 8 in. per cent.	Elastic limit (yield point), on original cross-section, lb. per sq. in.	Maximum stress, on original cross-section, lb. per sq. in.	Remarks.
1.109X0.006	0.0066	31.8	21.1	20.4	25.5	Fair break in center.
1.135X0.007	0.0079	17.7	20.4	28.4	28.4	Fair break in center.
1.114X0.005	0.0055	...	6.3	22.4	34.6	Specimen broke outside datum points on slightly larger area.
1.124X0.008	0.0089	...	14.4	22.6	27.7	Specimen broke outside datum points on slightly larger area.
1.114X0.01	0.0111	18.9	12.0	...	27.3	Fair break.
1.121X0.011	0.0123	24.4	20.0	18.2	27.3	Fair break.
Bending test. Strip bent three times upon itself.						No cracks.

Fig. 9 shows the result of some mechanical tests on copper pipes made by the centrifugal process and subjected to hydraulic pressure, giving results far above those required by the (British) Board of Trade.

The formation of copper trees and nodules was another difficulty which had to be overcome, but which had to be reduced to a minimum in the centrifugal process, for the reason that impurities held in suspension in the electrolyte have no oppor-

tunity of settling on the cathode, and all gas bubbles are swept from the surface on which the copper is being deposited.

Fig. 10 is a section of two nodules which illustrate the way in which they crystallize radially from a microscopic nucleus differing in their structure from the copper sheet which crystallizes at right angles to the surface of the cathode, as is clearly shown in Figs. 10 and 11, thus forming a weak line of cleavage, enabling the nodules to be easily separated from the copper sheet. For this reason it is impossible to produce a good sheet by any after-process of rolling.

The form of the nodules or trees is largely dependent on the amount of free acid in the electrolyte; if the percentage is high, the form is rounded; if the percentage is low, then the growth is more fern- or tree-like (Fig. 12).

The percentage of free acid employed in the centrifugal process is high, amounting to 12 or 13 per cent. The electrolyte,

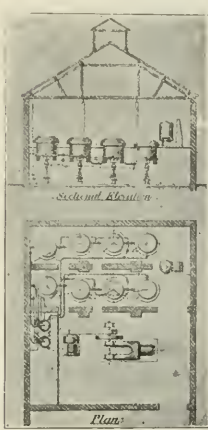


FIG. 17.—GENERAL ARRANGEMENT.

the usual composition of which is 12.5 per cent of copper-sulphate and 13 per cent of sulphuric acid at a temperature of 40° C., is kept in the cupric state and the impurities in suspension separated by means of a centrifugal filter provided with air lights and an atomizer for breaking the solution up into a fine spray, as shown in Figs. 13 and 14, respectively. It has been found that subjecting the solution to a strong light the impurities are more easily precipitated and no solution is kept in the cupric state.

The production of copper wire by electrolytic means is a more difficult problem than the production of copper tubes and sheets. Various processes have been suggested and tried from time to time, such as the electrodeposition of copper on thin wire until it has obtained a considerable thickness,

and then drawing the thickened wire down to a comparatively fine wire. Swan and Saunders have both experimented with such processes, but so far they have not been worked commercially.

Elmore's process consists of producing copper tubes by his burnishing process, cutting them into long spirals and then drawing them into wire.

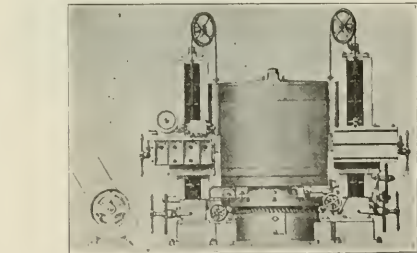


FIG. 18.—LATHE FOR UNWINDING COPPER STRIP.

Other experimenters have tried placing an insulated spiral strip on a cylindrical mandrel so as to produce long copper spirals, but such an arrangement only allows of a very low current density, being employed, on account of the nodules which form on the edges of the strip, even at very low current densities, rendering the strip unsuitable for drawing down into wire.

Copper wire is made by the centrifugal process in the follow-

ing manner: A mandrel similar to that used for making copper sheets is employed, around which a spiral scratch is made, the pitch being determined by the size of wire required.

The effect of the spiral scratch (which need only be very light, but must be angular) is to cause the crystalline structure of the copper to form a cleavage plane, as shown in Fig. 15. It will be observed that the copper divides exactly at the apex of the scratch; that is, the copper deposited in the scratch is equally divided and forms a small V-shaped fin on two sides of the copper strip, Fig. 20. If the scratch is not angular, but rounded at the base, the copper will not divide, as the crystals are radial, as shown in Fig. 16.

After the desired thickness has been obtained, approximating the pitch of the spiral scratch, the mandrel is removed from the depositing cell and placed in a vertical position on a lathe, Fig. 18, and the copper strip is unwound at an angle of about 45° to the face of the mandrel, Fig. 19. During the process of unwinding, the small tin or burr is removed by passing the wire through a suitable die and then through a wire-drawing machine provided with three or more draw-plates to reduce the strip to the desired diameter. By employing a mandrel of 6 ft. or 7 ft. in diameter, wire 4 or 5 miles long can be made in one operation.



FIG. 19.—MANDRELS SHOWING METHOD OF UNWINDING COPPER STRIP.

from ore without any intermediate process of smelting.

The centrifugal process is a step in this direction and is at least 10 times faster than any existing electrolytic process, and a high current density can be employed without deteriorating the quality of the copper. There is no risk of lamination, as no burnishers are employed. The plant is simple and free from mechanical complications and the amount of copper locked up for a given output is small compared to other processes. The process is of interest to mechanical engineers as it conclusively proves that to get a high tensile strength in metals, combined with ductility, it is not essential to put a large amount of work into the metals as hitherto has been considered necessary by the processes of swaging, rolling or drawing, but that a very small amount of energy will suffice when applied as described.*



FIG. 20.—SECTION OF COPPER STRIP, SHOWING CAUSE OF CLEAVAGE.

Mixing Machinery.

By OSKAR NAGEL, PH. D.

Mixing appliances may be subdivided into mixers for (1) solids, (2) solids and liquids, (3) liquids, (4) liquids and

*In an appendix to this paper Mr. Cowper-Coles gives diagrams representing his estimates of the savings which can be obtained with the centrifugal process in comparison with present practice. A typical analysis of the copper produced by the centrifugal process is given as follows: 0.0189 Fe, 0.0015 As, 0.0013 Ph, 0.0010 Sb, 0.0008 Bi, no Ag, no Ni, no S, copper (by difference), 98.9765. Under favorable conditions the theoretical weight of copper is said to be obtained. The cost of a plant for producing 10,000 tons of tubes, sheets and wire per year by the centrifugal process is estimated as \$670,000. The actual working cost of producing copper tubes, sheets, and wire by the centrifugal process direct from blister copper is estimated to be \$13.63 per ton. This is the actual working cost, on which there would be a further reduction of the precious metals recovered.

gases, and (5) gases. The following description is restricted to special mixing machines. Different machines, described in former articles, are also excellent mixers, for instance, pebble mills, and tube mills, which serve not only to reduce materials to an impalpable powder, but to produce a thorough mixture. For this reason manufacturers of tube mills, like the Abbe Engineering Company and the J. R. Alsing Engineering Company, also make mixing machinery. For the description of tube mills and other machines which also serve as mixers, the reader is referred to our former articles.

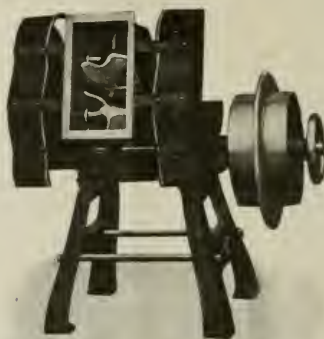


FIG. 1.—MIXER.

Very satisfactory and at the same time simple mixing machines for dry and wet solids are built by Werner & Pfleiderer, of Saginaw, Mich. Their rapidity of operation and the thoroughness of mixing account for the extensive use of these machines.

If the proper size of these machines is chosen, the most difficult mixing process can be successfully performed. It may

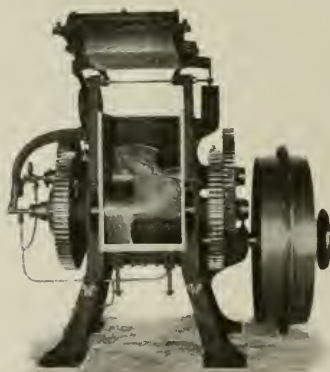


FIG. 2.—MASTICATOR.

be mentioned that these machines are used not only for mixing dry, but also wet materials. In the latter case they also act as kneading machines. The special features of these mixers and kneaders are as follows:

First, the peculiar kneading blades (mixing and kneading arms) are to be noticed; they are designed in different ways according to requirements. They revolve in two hollow half-cylinders, intersecting in each revolution successively every point on the surface of the surrounding cylinder, so that no

particle of the material can escape getting into the action of the blades.

The second feature is the reversing apparatus, by which the blades are made to revolve either backward or forward. The process of mixing and kneading is thereby accelerated and the discharge of the material greatly facilitated.

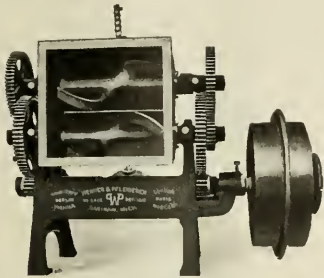


FIG. 3.—MIXER FOR HAND TILTING.

Thirdly, the troughs of the machines are shaped according to the requirements of the material to be treated, and are mounted so low that all materials can be charged and discharged conveniently.

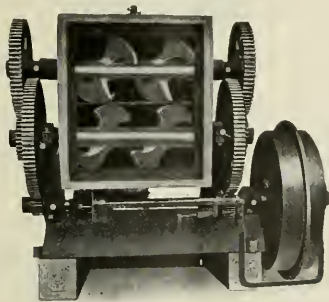


FIG. 4.—MIXER, WITH POWER TILTING ARRANGEMENT.

These kneading and mixing machines are of very solid construction, being usually built of iron and steel. For materials, however, which should not be brought in contact with iron, or for such cases in which the machines must be protected from the

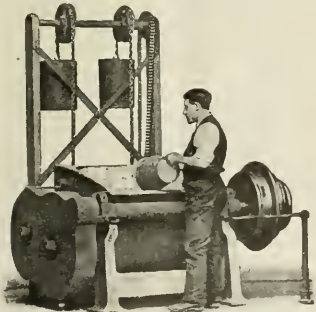


FIG. 5.—MIXER, WITH LOW TROUGH.

effect of acids, etc., the trough and blades of the machines can be zinc-plated, made of bronze or any other suitable material. For such cases in which iron must not work against iron, the blades are made of brass. In cases where the materials to be

treated exercise a severe bearing effect upon the trough blades, the trough is fitted with a movable lining and specially protected blades are provided.

The blades may be made hollow and the trough jacketed to permit heating by steam or cooling by cold water. Such arrangements are used where materials (gutta-percha, chewing

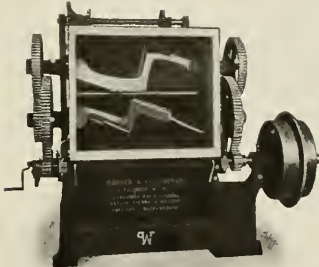


FIG. 6.—PAPER PULPING MACHINE.

gum, chocolate, licorice, etc.) require heating to facilitate the process of mixing and masticating or where cooling of the material is considered necessary or desirable.

These machines are constructed for slow as well as high speed, and also with an arrangement for two speeds so as to suit the numerous requirements of various industries. They are built in three strengths.

Class BS (gears on one side) are strong machines for kneading and mixing every kind of rubber cements, crucible paste, ointments, oils and powders.

Class BB (gears on both sides of the trough) are adapted for the manufacture of pill masses, red and white lead, stiff putty, smokeless gun powder, etc.



FIG. 7.—AGITATOR.

Classes BBB and C, the very strongest and heaviest built machines, are employed for very tough masses and for such cases in which occasionally extraordinarily sudden jerks and resistance are encountered, as with gutta-percha, india rubber, linoleum, celluloid, etc.

In the machine shown in Fig. 1 the trough can be taken apart with great ease, hence the trough and working parts can be cleaned and washed as scrupulously and perfectly as may be desired. For discharging contents it can be tilted, as shown in the cut.

The type "masticator," shown in Fig. 2, is a special construction for the kneading, masticating and malaxating of very tough masses. The trough and blades are constructed for heating by

steam; only two connections have to be made, one for steam inlet and the other for the waste steam. For cooling purposes cold water may be turned on same fittings instead of steam. In view of the great resistance to be overcome in treating very stiff materials, these masticators are very strongly built. The discharging of the material is effected by raising a flap door in front of the machine.

Figs. 3 and 4 are very rigid, all-around useful types. Fig. 3 is tilted by hand by means of a crank; Fig. 4 has a power tilting arrangement, which is set in action by a foot or hand lever. Fig. 3 can be fitted with a special device for mixing at fast and medium speeds materials the consistency of which changes during the treatment. These types are built for a capacity of 20 to 150 gal.

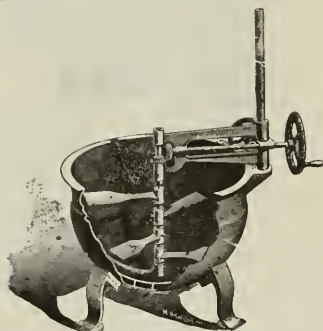


FIG. 8.—MIXER FOR LIGHT SUBSTANCES.

The distinctive feature of the machine shown in Fig. 5 is that the trough hangs very low in its frame, thereby rendering the charging and discharging of the machine more easy and convenient than with any of the other types. There are no steps needed and the attendant does not have to stoop to get access to the working parts inside the trough. The machine illustrated has hand-tilting gear, aided by counterweights, which makes the tilting arrangement by hand very easy and convenient. This machine, which is built in sizes ranging from a capacity of 20 to 290 gal., is also built with a power-tilting device, which is set in action by a foot or hand lever.

Fig. 6 illustrates the universal paper pulping machine built by the same concern. This machine consists of a trough with two

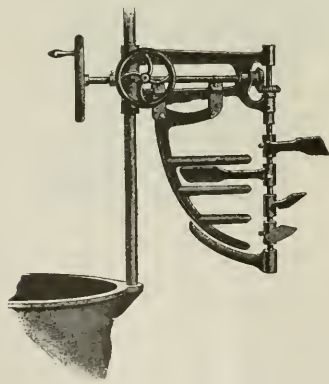


FIG. 9.—MIXER.

hollow half-cylinders in which revolve two agitators. These agitators intersect in each revolution successively every part of the surface of the surrounding cylinder so that no particle of the paper stock can escape getting into the action of the agitators, which tear it up and pulp it as thoroughly as may be desired.

This machine disintegrates all kinds of paper. It preserves and separates the fiber without breaking it and produces a pulp which can be made into very strong and highly finished paper.

Mixing of Liquids.—For mixing liquids preferably kettles are used which are provided with agitators. A great variety of these agitators are built by H. W. Dopp Co., of Buffalo, N. Y. In the machines built by this firm the mixers can be raised and lowered at will, which greatly facilitates removing of the contents or cleaning of the kettle. The agitator shown in Fig. 7 has an upright rack A screwed into a bracket cast on kettle. A



FIG. 10.—DOUBLE-MOTION TYPE OF MIXER.

pinion operated by hand-wheel E engages with this rack and thus the agitator can be easily raised or lowered, and on reaching the top can be swung to one side out of the way. The mixer shown in Fig. 8 is especially adapted for use of light substances, where it is desired to assist evaporation by agitation, or to keep a substance agitated to prevent burning. The

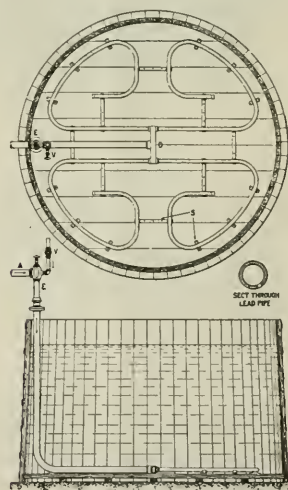


FIG. 11.—APPLICATION OF AGITATOR FOR CHEMICAL WORKS.

mixer illustrated in Fig. 9 has an additional arm conforming with the side of the kettle, from which horizontal arms project between the revolving arm of the mixer proper. It will be seen that these extra arms have a tendency to break up the substance to be mixed.

The mixer shown in Fig. 10, which is built by the same firm, is a double-motion type, i. e., both the large sweep to which are

attached the steel scrapers for keeping the sides of the kettles clean, and the horizontal paddles revolve; the latter acquire the speed of the former and in the opposite direction. This agitator is used for mixing thick substances. Various other types of agitators are built by the same company for special purposes.

Mixing of Gases and Liquids.—A very convenient apparatus for performing this operation and for stirring liquids by means of air is the steam jet blower manufactured by the Schutte & Koerting Co. The action of the steam jet agitator is based upon the fact that a steam jet issuing from a small nozzle into a larger carries along the surrounding air and gives this air a velocity sufficient to overcome a pressure of fully 8 ft. of water. The air escaping with great force from the holes in the pipe fixed at the bottom of the tank causes a violent agitation of the liquid surrounding it and stirs up and drives in all directions any solid matter or precipitates resting at the bottom.

The agitator is best placed so that its head stands above the highest level of liquid. The distributing air pipes have two rows of holes equally distributed and pointed downward. The number of these holes are fixed by the rule that the combined area should equal twice the area of the air pipe of the agitator. The diameter of holes should not exceed $\frac{3}{8}$ in.

The agitating arrangement is especially useful in chemical works, where the operation of stirring is frequently of importance. Fig. 11 shows the application of such an agitator. In this case the pipes are made of lead and rest on lead supports to give clearance between pipes and bottom of the tank, so that the air can blow against the bottom of the tank and keep the solution in circulation.

Another example for the mixing of gases and liquids is the production of sulphurous acid, as shown in Fig. 12. A is the

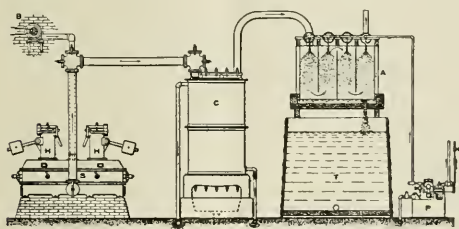


FIG. 12.—SULPHUROUS ACID PLANT.

absorption chamber with spray nozzles; B the blower for air supply; C the cooler; H the hopper; P the pumping outfit; S the sulphur furnace; T the storage tank. In this apparatus the blower forces the combustion air to the furnace, the sulphurous acid gases pass through the cooler to the absorption chamber where the gas is absorbed by the atomized water; the water pressure is operated by a pumping outfit, if there is no pressure water at disposal. The absorption chamber is so arranged that the gases have to pass up and down, being on their way absorbed by the atomized water.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special London Correspondent.)

Summer Meeting of the Institution of Mechanical Engineers.

Two papers read at Cardiff at the end of July last call for mention. That by Mr. SHERARD COWPER-COLES dealt with "The Direct Production of Copper Tubes, Sheets and Wire" (which is published in full elsewhere in this issue).

In the discussion which followed, the points raised were naturally more of a mechanical than of a metallurgical or electro-metallurgical character. For instance, Mr. E. P. Martin commented on the fact that thin sheets were cheaper to manufacture than thick sheets; another speaker asked about the tensile strength and behavior of tubes in actual place, and another

inquired as to whether bends could be made by the process. To this latter point Mr. Cowper-Coles, of course, had to reply in the negative.

A paper was then read by Mr. HUMPAGE on "The Evolution and Methods of Manufacture of Spur Gearing." Into its contents, which are of great interest and value mechanically, it is not necessary to enter in these notes. Mention must, however, be made of the discussion. A prominent motor-car manufacturer complained of the difficulty in car practice of getting the teeth of wheels the right shape after they had been case-hardened, owing to the distortion set up by this operation. It was important in the case of motor-car work that the teeth should be finished by grinding. Bevel gears in particular were troublesome in this respect, and a machine to set the teeth after they had been hardened would considerably improve matters.

Mr. Walter Deakin pointed out that a lot of trouble was due to the expansion of the cutter. When you started to work the cutter was cold, but if the metal was removed at any rate it got hot and expanded, and this gave rise to inaccuracy in the work. Something was wanted to cool the cutter or hob. A blast of air blown onto it, for example, would carry away the heat and so prevent it from expanding.

Mr. T. Clarkson first referred to the difficulty which exists in hardening hobs. He thought, however, that this difficulty would be considerably minimized with the electric furnace and suitable pyrometers. He preferred to work with non-hardened gears. He did not think grinding was necessary in all cases; in some instances, however, he believed in it. Bevels, he said, were very liable to distortion in hardening. He did not see any reference in the paper to a machine which was used some years ago for gear cutting. It had one cutter to cut any size of wheel, and it could cut internally or externally. Some years ago he had something to do with a turbine for driving a steam car. It was a De Laval turbine, and the gearing consisted of a couple of threads. He had seen the pinion running at several thousand revolutions per minute without the slightest trace of noise. He thought that this form of gearing might be used in some cases.

The Brayshaw Method of Hardening Tool Steels.

Electrically-heated furnaces in which fused salts are utilized have been employed for some little while. A new form of furnace, invented by Mr. S. N. Brayshaw, of Hulme, Manchester, is dependent upon gas or oil heating, and consists essentially of two chambers, the bottom one being slightly the larger and maintained at a higher temperature. By means of gas or oil heating the temperature of the lower chamber is raised to about 1400° C., while the upper chamber is at a bright red heat. A reducing atmosphere is obtained in the furnace by so mixing the gas and air (or oil vapor and air) before they enter the furnace that all local air currents which would oxidize the steel can be prevented.

The opening to the bottom chamber is covered by two hanging doors of fireclay securely held in iron frames. These doors slide horizontally along a bar, either together or independently. Furthermore, the bottom half of the doorway may be closed by a block which fits into it, thus restricting the height of the opening. At any moment, therefore, it is possible by simply sliding the doors to close them, either partly or wholly, and at the same time the hot side of the door is never presented to the operator, thus allowing him to work in comfort. The furnace body is of fireclay, bound with iron, and stands on an iron-table.

The tool to be hardened is first heated in the top chamber to a bright red heat, and is then transferred to the lower chamber, where it reaches the very high temperature required for the best results. It is then transferred to the salt-bath furnace, which is maintained at about 600° C. The tool slowly cools to the dull red heat of the salt bath, and is then removed and allowed to cool off in air.

It is claimed that, although the tool is cooled with such extreme rapidity, yet there is no risk of breakage, the cooling

being arrested at about 690° C., and the tool comes to an absolutely uniform temperature throughout before being removed from the melt. Any stresses that may be set up by the subsequent cooling in the air are very slight and are never sufficient to cause a crack.

Market Prices, August, 1908.

Tin has undergone a sharp fall during the month, commencing at £138 10 0, it kept about this price till the 11th, being then at £138 6 0. The price fell between the 11th and 14th £6 to £132 5 0. Since then it has rallied slightly to £132 10 0.

Copper started at £60, rose to £62 by the 10th, and has since fluctuated between £61 and £60, finishing at the latter price.

English Lead is fairly steady at £14.

Hematite fell on the 7th and subsequent days, afterward remaining steady. Started 57/6, finished 56/10.

Cleveland Warrants rose from 50/- to nearly 52/- on the 10th. Have since fluctuated between 51/- and 51/10.

Scotch Pig has remained between 56/- and 56/8 throughout the month.

Chemicals:

Sulphate of Ammonia f. o. b. Liverpool, per ton.....	£4	15	0
Copper Sulphate, per ton.....	20	0	0
Caustic Soda, white, 77 per cent, per ton.....	11	2	6
Bleaching Powder, 45 per cent, per ton.....	4	5	0
Antimony, Regulus, per ton.....	£31	0	0
Shellac, Standard T. N. Orange spots, per cwt.....	6	10	0
Carbolic Acid Liquid, 97 to 99 per cent, per gal.....	11		
Cresote, ordinary good liquid, per gal.....			2½
Naphtha Solvent, 90 per cent at 160 deg. C., f.o.b., per gal.			10.
Robber, Para fine, per lb.....	4s.	4	¾

SYNOPSIS OF PERIODICAL LITERATURE.

Fuels.

Analysis.—In *Eng. and Min. Journal* of Aug. 29 RANDOLF BOLLING gives some detailed methods in use in the laboratory of the Dominion Coal Company in checking up the work of the coal washers. The chemical part contains nothing new or novel. The physical test may be new. It is used to determine the work of the washers. A solution of CaCl_2 of exactly 1.35 specific gravity is prepared. Two hundred grams of coal or 100 grams of slate refuse are accurately weighed out and poured into a liter of this solution, care being taken that every particle is completely wetted. After standing 10 minutes the coal floating on top is skimmed off, washed by decantation, dried and weighed. The solution is siphoned out after each test and used over again, CaCl_2 being added to maintain the required gravity.

Charcoal Versus Coke for Blast Furnaces.—The comparison of two different fuels under so near the same conditions rarely takes place under such auspicious circumstances as that noted by R. H. SWEETSER in *Iron Age* of Aug. 13. At the plant of the Algoma Steel Company, Sault Ste. Marie, Ont., two modern blast furnaces were run for four months, one with coal and the other with charcoal as fuel. The furnaces were nearly exact duplicates of each other, one being 10 ft. higher. The ore mixture was exactly the same and, of course, climatic conditions were alike. No trouble at all was experienced in using charcoal in the 70-ft. furnace, the previous coke practice serving in running the same. Considerable less charcoal was consumed than coke for the same iron output, but one-third as much limestone was required and but 65 per cent as much blast was blown into the furnace fed with charcoal as the one using coke per ton of pig iron made.

Secondary advantages arising out of the use of charcoal as fuel were less material to handle, less blowing capacity required, less steam, less hot-blast stove area, lower blowing pressure less fine dust carried over in the gas, less cooling required in the lower part of the furnace, entire freedom from the production of a high-sulphur iron. Two thousand and eighty-three pounds of charcoal, as against 2207 lb. of coke, per ton of iron were used. The charcoal was of low grade, fuel consumption of only 1600 lb. to 1800 lb. per ton of iron produced being claimed for higher grades. The article contains a chart showing blowing conditions during the test. The failure of the char-

coal supply necessitated the use of part coke after four months, and finally the change to all coke. With the gradual replacement of the charcoal by coke the volume of the blast and the pressure of the same increased rapidly as the proportion of coke used increased. The chart shows this very clearly.

Two disadvantages of the use of charcoal as fuel are, first, the great scarcity of the same, and, secondly, the danger of ignition. The charcoal furnace required a pile of cordwood a half a mile long to supply the necessary charcoal for a day's run. Dirty, low-grade charcoal is very likely to cause numerous hangs and slips. Accompanying these is usually a large amount of fine charcoal dust thrown out of the explosion doors, it immediately igniting on striking the air, and at time the flames from such explosions reached to the ground. With clean charcoal this trouble is not so evident.

Furnaces.

Zinc Refining.—In the August number of *Brass World* a novel furnace is described for the refining of leady spelter. In general, it may be said that in the distillation of leady zinc the boiling of the metal keeps the same well stirred up and the lead is carried over probably mechanically. To avoid this stirring the new furnace is designed to heat the top surface of the bath causing volatilization from that surface without stirring up the molten mass. Opportunity is given for the lead to sink to the bottom and remain there undisturbed. The furnace is the invention of Richard Ziessling, of Grasselli. (See also the analysis of Ziessling's patent on page 381 of our September issue.)

Enamel Furnace.—In the manufacture of small quantities of high-grade enamels the crucible is the most satisfactory system of melting. However, where large quantities of enamel are needed the furnaces used are best constructed somewhat like the pots of the glass works. These furnaces when used for the fusion of enamels must have large fire places and high bridges to keep the ashes out of the melting pot. Even the draft should be sluggish to prevent the lighter particles from being carried over. In *Iron Age*, Sept. 3, drawings and description of such a furnace are given by JOSEPH VOLKKOMMER. For fusing the enamel to metals a muffle furnace must be used. Descriptions and drawings of two such furnaces are also given. Sulphur seems to be quite as big an enemy of the enameller as the iron worker. It is blamed for causing blisters on the enamelled ware. In the use of a muffle furnace with imperfect muffle in this industry an excess of oxygen must be used so that no reducing agents exist in the combustion gases, they causing blistering and discoloration of the product.

Iron and Steel.

Corrosion.—In the iron and steel industry the question of corrosion is foremost. The paper read by A. S. CUSHMAN at the Atlantic City meeting of the American Society for Testing Materials, June, is reprinted in full in the *Chemical Engineer* for August. The author's theory of electrolytic corrosion has been fully covered by us in various articles last year. (See our Vol. V, pp. 254, 257, 270, 343, 363 and 364.) HENRY M. HOWE and BRADLEY STOUGHTON are preparing a report for the same society showing that steel is less readily corroded than the purer wrought iron. They state that the presence of slag in wrought iron is no reason why it should be more resistant to corrosion than steel. The small amount present covers but little metal, and really may increase corrosion because of the difference of potential between it and the metal. (It should not be overlooked that electrolytic corrosion requires the completion of a circuit and slag is usually considered a rather good insulator, even the highly ferruginous slags of the puddle furnace.—ABSTRACTOR.) In the series of tests cited it is true that the authors show that steel is more resistant to corrosion than iron, but varied as the conditions are it seems in view of the preponderating data collected on this subject, the test cases are perhaps selected on a somewhat partial basis. R. E. HORTON in *Engineering News*, of Aug. 20, cites a new cause of corrosion. From a number of cases of corrosion which he noted,

particularly the pitting of the ends of the gates and vanes in high-head turbines, he concludes that the bulk of the trouble is due to defective design, leading to shocks and eddies in the passage of the water through the turbines.

Manganese Sulphide in Steel.—Manganese sulphide has never been considered a source of danger in steel rails, yet, according to the reprint of a paper read before the June meeting of the American Association for Testing Materials, by HENRY FAY, it may become an extremely dangerous material. A number of rail fractures were examined and this compound was found to be the cause of a great deal of the trouble formerly laid to gas and rolling flaws. Metal containing much sulphur to which manganese has been added should not be rolled at high temperatures on account of the squeezing out of this compound into dangerous plates and threads (M. P. of MnS determined as 1162° C., and showing considerable plasticity below that temperature). Specifications should limit more generally the amount of sulphur allowable in steel and the metal should be allowed to stand after the manganese additions to allow the MnS formed to float to the top. (In this connection the article by Geilenkirchen and Osann, printed elsewhere in this issue, on the removal of sulphur from steel in the electric furnace will prove interesting reading.)

Copper.

Alumina in Copper Blast Furnace Slags.—The behavior of alumina in the copper blast furnace has always been in question. C. F. SHELBY in *Eng. and Min. Jour.*, Aug. 8, cites the analyses of 11 slags from furnaces which have shown more or less good working, and in every case where the furnace was working well calculates the oxygen ratio of the slags, alumina included as an acid, to be almost exactly 2. Bad working of the furnace accompanies deviation from this figure. The slags were of widely varying composition; SiO_2 , 34.3 to 48 per cent; Al_2O_3 , 2.05 to 12.6 per cent; FeO , MnO , 19.9 to 37.6 per cent; CaO , 8.21 to 25.83 per cent; MgO , no to 12.9 per cent; BaO , no to 6.2 per cent. Zinc oxide seems to play no especial chemical rôle, it being either dissolved bodily in the slag as such or else in the metallic state, as is evidenced by the zinc flame and the oxide formed when the slag is tapped. This latter case is believed to lie at the basis of the fact that zinc in the charge tends to cause the slag to carry out the precious metals, they being alloyed with the zinc in the metallic state and carried out with it in the slag. The author does not believe that it is possible to replace all the silica by alumina as the slag becomes too thick and pasty. The high oxygen ratio of the Mansfield slags, 3.5, is due to the fact that they carry a large amount of alkali, a purely alkali slag with a ratio of 8 being possible.

Leaching Copper Slag.—A description of the Westby-Sorrenson process for the leaching of copper slags is found in the *Eng. and Min. Jour.* for Aug. 29, the author, E. P. JENNINGS, having been concerned in its development. Although the process is not now in use it presents some novel features which make it worth while reviewing. The process consists in passing the gas from the roasting furnaces through moistened granulated slag, the sulphur dioxide in the gas decomposing the wet slag and permitting the recovery of the copper in the same. The copper is converted into a sulphite, sulphate and thionate, and is precipitated as Cu_2S on boiling the solution of the thionates. The slag, granulated to 40 mesh, was placed on inclined shelves in a tower and moistened by allowing water to drip down from the top. The gases passed over the shelves.

The Fume Problem.—The Shelby Smelter, in California, has been experiencing a great deal of trouble with the fume question. They have recently installed the Cottrell process for condensing the fume, a description of which is published in *Eng. and Min. Jour.* of Aug. 22. The installation is reported a success. The process is essentially an electrostatic one. Two opposed electrodes are charged to a high potential by direct current and the current of gas to be purified is passed between

them. One of the electrodes is so arranged that a brush discharge takes place from its surface, the other so it does not. The solid particles in the gas touching the first surface are first electrified, then repelled into the gas current, where they attach themselves to the surrounding particles and fall to the bottom or are attracted by the other electrode. In the actual apparatus as installed, one electrode is made of wire gauze wrapped with asbestos cord and suspended inside a cylindrical iron vessel forming both the container of the apparatus and the other electrode. The gas to be purified is passed up between the two electrodes. Asbestos makes an ideal material for yielding the required brush discharge. On account of the high potential used special means must be provided for insulating the two electrodes and keeping the dust from short-circuiting them.

The same smelter recently erected a bag house, a description of which is also given in the above *Journal* of Sept. 3. Reinforced concrete was chosen as the construction material, it being protected from the corrosive action of the very moist fumes by tiling of firebrick. Three thousand eight hundred and twenty-three square feet were allowed for each cubic foot per minute of the maximum amount of gas the house would ever be called upon to filter. At the start 4,1716 sq. ft. were allowed for each of the 55,000 cu. ft. per minute of gas passing through the house. The temperature of the gas is $112-114^{\circ}$ Fahr., and the fan pressure 0.625 oz. The designers now consider it safe to allow 1.14 sq. ft. of bag surface to each cubic foot of gas to be filtered per minute.

Converter Process at Mansfield.—In an article on the "Progress in Metallurgy in 1907," R. HOFFMANN, in *Chemiker Zeitung* for Aug. 15, mentions the application of the converter process to the Mansfield mattes. The process was in itself successful, but the stringent government regulations, regarding the setting free of the sulphur dioxide in the atmosphere preclude its present application. The old chamber process of converting the gas into sulphuric acid works too slow to take care of the enormous volumes of gas set free in the short time of the operation. A rapid contact method which will not clog when forced is necessary before the process can be permanently installed.

Lead and Zinc.

Silesian Practice.—The smelting practice in the zinc and lead district in Silesia is the subject of an illustrated article in the *Eng. and Min. Jour.*, for Aug. 8, by J. S. G. PRIMROSE. This district is gradually introducing the air recuperative type of muffle furnaces and discarding the Siemens regenerative type. The charges made into the D-shaped retorts consists of equal parts of roasted blende and pieces of roasted calamine and smithsonite 3 cu. in. to 5 cu. in. in size. A degassed coal is used for reducing agent. Seventy to 75 per cent represents the standard recovery. The government does not allow gases with more than 2 per cent sulphur dioxide to pass into the atmosphere. In the older plants these gases from the roasting furnaces were passed through brushwood towers through which milk of lime dropped. Trouble was experienced with contact sulphuric acid plants by the sponge clogging up, though this has lately been overcome.

Zinc Ferrites.—In the *Eng. and Min. Jour.*, Aug. 29, J. S. C. WELLS reports the result of a study of the ferrites of zinc. Compounds as basic ZnOF_2O_3 were formed by heating mixtures of zinc and iron oxides for several hours at 800° . They are insoluble in ordinary leaching agents and may explain the cause of so many of the leaching propositions being failures when tried on commercial zinc ores.

Nickel.

Nickel Plating.—In his review of the "progress of chemistry in the year 1907, with respect to the plating industry," H. STOCKMEYER, in *Chemiker Zeitung*, Aug. 5, thinks the cause of the peeling of nickel plating is the presence of hydrogen in the same. Less hydrogen is included in plate made in a hot solution than in a cold one, and it is recommended to run the bath

Physical Properties.

Determining Hardness.—For determining the hardness of metals a new instrument is described by J. F. SPRINGER in *Iron Age*, Aug. 26. It is called the Shore scleroscope. The principle on which the apparatus is based is as follows: A hammer with peculiar shaped face is allowed to fall on a piece to be tested and the height of the rebound is measured. The apparatus is compact, the hammer being fixed in a glass tube with bulb lift and trigger release. A scale and reading glass allows of close readings of the rebound being made. A chart shows very close agreement with the Brinell method. Some determinations of hardness made with the instrument are given below:

Compressed. Uncompressed.

Lead	2	3
Babbitt	4-9	..
Copper	6	14-20
Zinc	8	30
Brass	12	26
Gold coin	..	14
Wrought iron	18	30
Type metal	20	21
Hard brass	20-25	35-40
Nickel	27	..
Hard brass	30	35
Steel rails (0.4 to 0.5 carbon) annealed.	26-30	..
Tool steel (1 per cent carbon and above) annealed	31-35	..
Mild steel, cold rolled	..	35
Tool steel (1 per cent carbon) cold roller	..	35-40
Gray iron, cast	39	..
Tool steel, unannealed	40-50	..
Tool steel, self-hardening	60-85	..
Tool steel (unalloyed) hardened	90-110	..
High-speed tool steel	80-105	..
Porcelain	120	..
Glass	130	..

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Induction Furnace.—J. Hården, 897,203, Aug. 25, 1908. Application filed May 8, 1908. (Assigned to Grondal-Kjellin Co., Ltd.)

Fig. 1 shows the construction. The feature is the removable hearth or lining, so that when repairs become necessary, the furnace charge may be run off into a ladle, while a fresh hearth or lining is being substituted for the defective one. A is the central core of the magnetic circuit of iron; the primary coil is wound thereon. B is the bed or framework on which the furnace stands. C is the annular fusion chamber (the secondary). The hearth or lining D is built or stamped in a metallic casing E, which is independent of the other parts of the furnace and attached to the framework by bolts E. The casing E is provided with hooks F so that it can be lifted from the body of the furnace by means of a crane.

Artificially Cooled Electrode.—Fred. M. Becket, 896,429, Aug. 18, 1908. Application filed Nov. 24, 1902.

The electrode, shown in Fig. 2, consists of a carbon or graphite shell 5, and interior metallic portion 1. The latter is hollow and is artificially cooled with water. Cast iron and wrought iron are satisfactory for the metallic portion, but the most efficient metal is a ferrotitanium alloy containing 7.5 per cent of titanium. Its melting point is 300° C. above that of wrought iron and 500° C. above that of cast iron. Further, it is much tougher and less brittle than ordinary cast iron and can be easily machined. With this construction the carbon is kept cool

and preserved from exposure to air. The chief advantage of cooled electrodes is that "for the same amount of energy consumed the cost of reduction is considerably lowered. A series

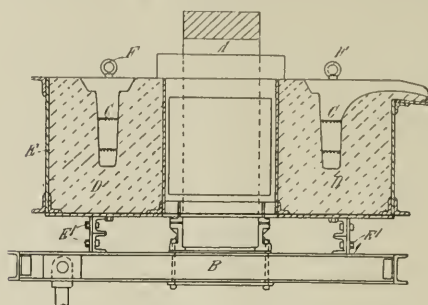


FIG. 1.—INDUCTION FURNACE.

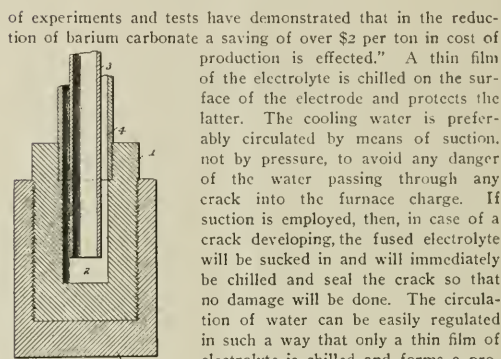


FIG. 2.—ARTIFICIALLY COOLED ELECTRODE.

charge on the electrode surface becomes too thick, it acts as an obstruction.

Calcium Carbide as Reducing Agent for Ferro-Alloys.—

F. M. Becket, 808,173, Sept. 8, 1908. Application filed May 25, 1908. (Assigned to Electro-Metallurgical Company.)

If calcium carbide is used as reducing agent at a sufficiently high temperature in an electric furnace for the reduction of oxide ores of chromium, tungsten and vanadium, both the calcium and carbon constituents of the carbide may be oxidized with such degree of completeness that the metallic product obtained contains less carbon than would be the case if carbon alone were used as a reducing agent. In the preparation of silicious ores the calcium oxide produced acts as a flux. In case of highly silicious ores it is necessary to add additional lime.

Electrode Renewals.—G. O. Seward and F. von Kügelgen, 898,601, Sept. 15, 1908. Application filed Feb. 21, 1906.

The production of ferrochromium and similar alloys is carried out in a continuous process, the furnace being kept full of fresh charge material to such a height at the top that the heat losses are a minimum and the carbon electrodes are cool where they emerge from the charge. For renewing an electrode, the latter is not removed (because the cold charge would fall into the cavity left and relighting of the arc would be very difficult). The electrode is left in the charge, but the holder is removed and a new length of carbon electrode is screwed onto the piece left in the charge. The holder is then connected again and a progressing feeding of the electrode is thus effected.

This method is easy with graphite electrodes, because they can be easily machined.

Electric Furnace for Distillation of Metals.—J. H. Reid, 896,413, Aug. 18, 1908. Application filed Aug. 5, 1907. (Assigned to Electric Smelters, Ltd.)

The furnace comprises three chambers discharging into each other. Each chamber is provided with electrodes for producing an arc, and with nozzles for the introduction of reagents and steam, and with outlet pipes leading to condensing tanks. A vacuum is produced in each chamber by means of an exhausting fan and the metals which sublime under the action of the arc are drawn off into the condensing tanks and are condensed.

Electrolytic Processes.

Electrodeposition of Brass.—S. O. Cowper-Coles, 898,189, Sept. 8, 1908. Application filed Aug. 2, 1907.

For the electrodeposition of brass, the inventor uses brass anodes together with separate zinc anodes and copper anodes, the latter being in series with adjustable resistances so as to adjust the current passing through the copper or zinc anodes separately. An electrolyte of double cyanides of copper, zinc and potassium is employed which is prepared as follows: A 10 per cent solution of cyanide of potassium is brought to the point of saturation by passing an electric current through a brass anode, the cathode being protected by a porous pot, and the electrolysis is continued as described above, small quantities of cyanide of potassium being added from time to time as found necessary.

Hypochlorite Apparatus.—E. Weichert, 896,184, Aug. 18, 1908. Application filed Oct. 24, 1906.

In order to protect electrolytic hypochlorite apparatus from the effect of heat set free in the process, the author passes the electrolyte through a cooled coil made from clay arranged horizontally and situated in a cooling chamber. The upper parts of the windings discharge into chambers in which the electrodes are so arranged that each chamber has a positive and a negative pole. Each winding of the cooling coil joins two chambers, so that the solution enters the first chamber and is here electrolytically treated. It passes through the first winding of the coil and is at the same time cooled. It then enters the second electrolytic chamber, where it is again submitted to electrolysis. The solution next passes through the second winding of the coil and is thereby again cooled, and then enters the third electrolytic chamber; and so the process of electrolysis and cooling is alternately repeated until the liquid has passed through all the chambers and all the windings.

Concentrating Pickling Solution.—G. W. Nistle and R. L. Gifford, 896,749, Aug. 25, 1908. Application filed June 22, 1907.

In pickling sheet iron in a solution of sulphuric acid, the acid solution becomes finally unsuitable for the process; it is then customary to neutralize all free acid by throwing scrap iron or filings into the solution and to concentrate the solution by heating it. On cooling iron sulphate crystallizes out, which is recovered as a by-product. The inventors heat and cool the solution by means of coils of brass or copper and connect these coils by an electric conductor with the basket containing the scrap iron. This arrangement represents a short-circuited galvanic cell, in which the iron basket is the anode. The neutralization of the free acid and the concentration of the solution are thereby accelerated.

Electrolytic Cell.—G. C. Landis, 896,555, Aug. 18, 1908. Application filed Sept. 17, 1907.

The construction is shown in Fig. 3; the upper diagram is a horizontal section, the lower diagram a vertical section. a^4 is the inlet, a^5 the outlet for the electrolyte. The tank contains a number of units B, each complete in itself and interchangeable with any of the others. Each unit B consists of a framework

and two graphite plates, C and C', one being suspended from the top, the other from the bottom. They form a series of baffle plates, the electrolyte passing through the cell in a circuitous path, above one plate, then below the next, and so on. These plates are not connected to the external circuit, but act as intermediate bipolar electrodes. Only the two end plates d^2 and d^3 are connected to the external circuit.

Batteries.

Nickel and Cobalt Flakes or Scales.—T. A. Edison, 896,811, Aug. 25, 1908. Application filed Feb. 6, 1900.

In his storage battery, Mr. Edison uses thin flakes or scales of nickel or cobalt in contact with the particles of active mass in order to reduce the internal resistance. This latest method of making these flakes is as follows: Thin nickel films are made by electro-deposition and reduced to the desired size. They are

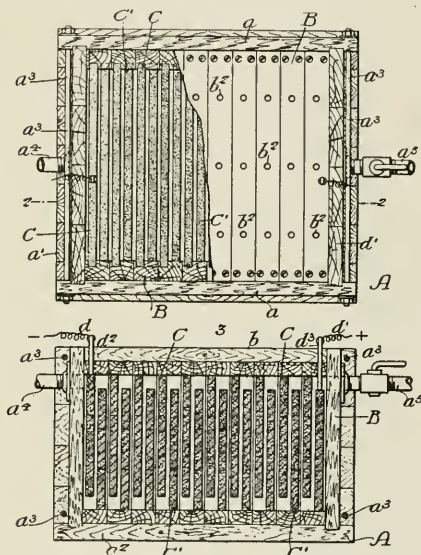


FIG. 3.—ELECTROLYTIC BELT.

then heated in an oxidizing atmosphere so as to oxidize the surface particles together with the impurities, such as iron and arsenic. The films are now reduced in an atmosphere of hydrogen and are then treated in an acid solution to leach out the impurities (for instance, in a mixture of nitric and hydrochloric acid to remove the iron and arsenic). The films thus get a rough matted surface whereby their contact with the particles of active material is improved.

Storage Battery.—T. A. Edison, 896,812, Aug. 25, 1908. Application filed March 18, 1908.

"In a storage battery, a supporting plate, a plurality of tongues carried thereby and pockets secured by said tongues, said tongues being capable of being bent into such position as to permit the pockets to be separately removed from the said plate." (Claim 1.)

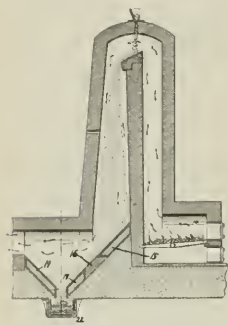
Storage Battery.—L. Fiedler, 896,981, Aug. 25, 1908. Application filed Feb. 25, 1907.

The second claim refers to "a plate for secondary batteries, comprising a grid having interstices therein, said interstices being filled by molded portions of prepared lead oxide of a hard, compact and porous nature, inserted in the interstices, while in soft, pasty condition, due to the mixture of lead phenylate-acetate with lead oxide."

RECENT METALLURGICAL PATENTS.

Furnaces.

Magnetic Roast.—The report that the Dennis system of roasting, the essential feature of which is the passage of fuel gas and ore in the same direction through the furnace (our Vol. IV, page 463) is doing quite nicely in the distillation of mercury, adds interest to a method of Arthur R. Willey for a furnace preparatory to magnetic separation, since it involves the same fundamental principle. While this method of Willey was already noticed in our Vol. V, page 330, his latest patent (898,024, Sept. 24) contains some further interesting details. Heretofore it has been attempted to obtain a roast of this character by dropping the ore downwardly in a shaft containing an upwardly traveling current of hot air and flame. This has resulted in overheating the finer or lighter particles of ore, and insufficiently heating the heavier particles of ore, for the reason that the falling or downward travel of the finer particles is retarded by the upwardly traveling hot air current, while the heavier particles are of sufficient weight to fall directly downward. Hence the finer particles which require less time for roasting are subjected to the heat during a longer period than the coarser particles, thus giving results exactly opposite those desired. By causing the ore to be treated, to move downwardly in the same direction as the heat current, this difficulty



ROASTING FURNACE.

is overcome; and by providing a cooling medium, preferably a water jacket, at the bottom of the shaft or roasting compartment, with which the falling particles of ore come in contact, the evil influences of excessive heat (attended by the clinging of the ore particles together) are overcome. The finer particles of ore are at once sufficiently cooled by contact with this jacket, and it is these particles that are exceedingly liable to be heated too much, while the coarser particles, though only partially cooled by their first contact with the water jacket, will be sufficiently cooled before they leave the furnace by reason of the extensive water jacketed surface with which they are brought in contact before they reach the atmosphere. It is intended to cool the entire body of ore below the roasting point before it reaches the outer air, since otherwise there would be danger to overroast the outer layer of the mass. The furnace construction is shown in the adjoining diagram. The fire box is at the bottom at the right. The hot gases pass upward around the top of the dividing wall and downward on the left together with the finely divided ore introduced at the top. The portions 15, 16, 17, 19 are water-cooled. The roasted and cooled particles of ore drop on the vibrating trough 22, which is also water-jacketed and provided with means for excluding atmospheric air from contact with the ore until the latter is fed out.

Blensing's Gases and Fumes.

Fume Arrester.—Henry Howard (896,111, Aug. 18) patents an apparatus for removing suspended solid particles from hot gases and fumes. It has two parallel chambers, each of which contains a considerable number of superposed horizontal shelves, vertical passages at the ends of these shelves serving to receive and deliver the gases by means of a valve-controlled inlet at the upper end of one passage and a valve-controlled outlet at the lower end of the other passage. The valves enable the gases to be delivered at will through either or both chambers. The horizontal shelves are, of course, intended to receive the

deposit of the solid particles. The essential and interesting feature of the apparatus is that the inlet is at the top of one vertical end passage and the outlet at the bottom of the other vertical end passage. The explanation is that an equal distribution of the gas passing through the apparatus over all the different shelves is thereby insured, simply as a result of the different specific gravity of hot and cold gases. If too much of the hot gas would flow through the upper shelves, a back pressure of hot gas would be produced in the vertical passage at the exit. This refers, of course, to the case that the gas to be cleaned is hotter to the atmosphere. Special experiments of the inventor have shown that when the gas inlet and outlet were both located at the top of the vertical end passages the efficiency of cleaning was actually less than when the superposed shelves were entirely omitted. If the object is to clean gases which are cooler than the atmosphere, the inlet must be located at the bottom of the supply passage and the outlet at the top of the discharge passage. By employing a large number of closely spaced plates, it is possible to obtain a separation of solid particles practically as complete as that effected by a filter, while the shelves offer little resistance to the flow of gases.

Copper.

Copper Castings.—In casting copper or copper alloys, the presence of oxide of copper tends to prevent the attainment of a perfectly even structure of the casting. For the same reason it has hitherto been impossible to add copper or its alloys to iron or steel in large or at least in such quantities as to impart to the metals greater hardness or strength of resistance than that of the ordinary alloys. In order to enable the addition of iron and the like, the assistance of other metals, such as zinc, aluminium or nickel, has been requisitioned, which act to a certain extent as carriers for the iron. C. Gautsch (898,638, Sept. 15) recommends the use of bicarbonate of soda. His method consists in adding to the metal—copper or mixtures of copper, tin, old metal and iron, steel or the like—besides the usual addition of phosphorus (which tends to reduce the copper oxide formed) a suitable quantity of bicarbonate of soda, a part being advantageously added right at the commencement and a part after the metal has been melted. The amount of bicarbonate of soda added may be from 1 to 2 1/3 per cent. It is stated that the bicarbonate of soda causes the mass to foam and procures an intimate mixture while the oxides of copper pass into the slag.

Hardening Copper.—H. V. Draper (896,632, Aug. 18, 1908) proposes to harden copper by melting it and adding pulverized alum and arsenic (1 lb. of alum and 4 oz. of arsenic per 20 lb. copper). After thorough stirring the metal is poured into molds.

Lead.

Lead Alloy.—G. F. Allen (897,953, Sept. 8, 1908) patents a lead alloy for which high tensile strength is claimed and which is said to be specially useful for lead pipes. It contains from 3/4 to 5 per cent of zinc, the balance being lead. The only claim, however, refers to from 1, 4 to 5 per cent of zinc.

Iron.

Refining Iron in the Cupola.—M. Ruthenburg (898,068, Sept. 8) refines pig iron in an ordinary foundry cupola by mixing it with iron ore in definite proportions (for instance, in equal quantities) and subjecting it to the fusion temperature. Two products are obtained: first, iron containing less sulphur and phosphorus than the original pig iron or ore, and, second, ferrous cinder containing most of the sulphur and phosphorus. A mixture of equal quantities of pig iron, No. 2 Buffalo (0.75 P, 0.15 S, and 3.25 C) with iron ore (62.7 Fe, 0.6 P, 0.12 S) was treated in an ordinary foundry cupola furnace. The amount of coke used was 15 per cent of the weight of pig iron and ore. The iron obtained weighed 80.75 per cent the aggregate weight of pig iron and ore, and analyzed 0.5 P, 0.095 S, 2. C. and had a 50 per cent higher tensile strength.

A Modern Steel Foundry and Machine Shop.

By C. A. TUPPER.

The largest steel foundry of the West, for the making of general castings—viz., that of The Falk Company at Milwaukee, Wisconsin—has many features of special interest, above all the economical arrangement and operation of the works.

Foundry.

While the business of The Falk Company started in an establishment devoted especially to the manufacture of street-railway motor-gears and track appliances, and that department still constitutes an important one, a visit to the foundry and power plant is particularly interesting. The foundry is in a building 625 ft. long by 295 ft. wide at its largest part, of brick and steel construction, and has a capacity of 1500 tons monthly. Steel castings of any size required up to 40 tons capacity or more and varying widely in character, are turned as readily as is usual in the work of a smaller plant devoted to a standard line of apparatus.

To-day the custom or jobbing foundry fills so important a place in machinery-building, particularly for the production of steel castings, that manufacturers using this material are vitally interested in the facilities afforded by the various plants available to them, and it is from the standpoint of The Falk Company's customers, with one of the largest of which the writer is connected, that the following description has been prepared.

This begins with the unloading of the raw material and is designed to follow the work, step by step, through the various processes by which it progresses to the finished casting. It shows at each stage something of the equipment and system which make for the most satisfactory and reliable results—results upon which manufacturers may depend, not only during the ordinary course of business, but also in times of emergency.

Pig iron, brought in over the C., M. & St. P. Railway and left standing in cars on any one of the tracks which occupy a considerable portion of The Falk Company's ground, is unloaded by means of a Cutler-Hammer two-ton lifting magnet, at the end of a locomotive crane, and placed in piles between the tracks. An average analysis of each pile of pig iron or scrap is then taken and the magnet is again called into play to load the iron directly into charging buckets carried on small industrial trucks, which, after passing over a Fairbanks-Morse scale and having a record of the weight and contents of the buckets taken, are drawn up an incline to the charging floor of the furnaces and there lined up on tracks.

Thence they are picked by charging machines, as needed, and fed to either one of the two acid open hearth furnaces, of 15 and 20 tons capacity. The tilting hearth, supported on a heavy frame work of structural steel, forms the central portion of each furnace, and checker chambers and slag pockets are constructed at the ends, flues being provided for the admission of air in proper quantities to the combustion chamber. These furnaces, with all their accessories, were built by the Wellman-Seaver-Morgan Co. Every lot of pig iron, scrap, furnace lining, etc., is bought strictly on specifications and care is taken to see that the latter check with the analysis made by the company's chemist.

The fuel in the furnace is oil, which, after delivery in tank cars, is stored in three underground steel tanks in a concrete vault holding 15,000 gallons apiece. From those tanks the oil is pumped to the furnaces and a mixture of oil and air fed in together.

Four heats a day can be taken when required. Special heats of nickel-steel and chrome-steel castings, as well as those requiring a very high carbon content or particularly high tensile strength, are made when orders are received of sufficient tonnage, as is frequently the case.

From the tilting furnaces the liquid metal, after having the "doctor" added, is taken by four 25 to 30-ton oil-heated ladles, with bottom taps, two of which are used simultaneously, and

is carried by traveling cranes, as usual, to the various parts of the foundry where the castings are to be poured. With large molds, one of these ladles is emptied in a relatively short time. Opposite the furnaces are the core ovens, core room and temporary sand storage bins, with charcoal storage at the right. When an order is received and the patterns ascertained to be, or have been put, in proper condition to mold, the core department receives its instructions immediately, and at the same time it is learned whether the necessary flasks are available and in proper condition, so that there may be no delay on the molding floor when the men are ready to take up the work. This might be taken as a matter of course; but in a custom foundry, especially, where the work varies so much, it requires the best of system to keep the flasks in order and properly mated. Failure to do so, often means delay and sometimes serious loss to the customer.

After coming from the ovens the cores are closely inspected and any defects at once remedied. The core frames, as in all good foundry practice, are so constructed as not only to support the cores while they are being baked, but also form part of the trucks used to transport them from one place to another.

The loam and dry sand molding is done in a part of the foundry distinct from the green sand floors.

The foundry, which has been built with high head room, is built by Pawling & Harnischfeger, of Milwaukee. Two of these have an 80-ft. span, with a capacity of 50 tons each; five are 50-ft. cranes designed to carry 30 tons each, and there is one of 25 ft. span rated at 10 tons. All of the cranes have large overload capacity. Jib cranes, telephers and tracks running throughout the yard and shops complete the transportation system.

The various floors of this plant are provided with a thoroughly up-to-date foundry equipment, including special machines and mechanical appliances of the latest design. Among them are molding machines of the "power squeeze" and "hinged" types manufactured by the Tabor Manufacturing Company of Philadelphia, designs of the Pneumatic Machine Company in Zelenople, Pa., the Rowlands Machine Company's adjustable table pattern and rollover, straight-drop style of E. Killing's Molding Machine Works in Davenport, Iowa; pneumatic hoists built by the Curtis & Co. Manufacturing Company of St. Louis, and Pawling & Harnischfeger of Milwaukee; cold cut-off saws furnished by the Espen-Lucas Machine Works and the Newton Machine Tool Works, both of Philadelphia, the former of which are equipped with Disston inserted tooth blades and the latter with Taylor-Neubold blades; sand mills with shelf-discharging pans, built by Thomas Garlin's Sons Company of Pittsburg; pneumatic shaker screens and riddles of the design of the Hanna Engineering Works of Chicago; machines for straightening core wires or gagers purchased from the J. D. Smith Foundry Supply Company of Cleveland; hack saws and tumbling barrels of The Falk Company's own make, the latter for use in cleaning the smaller castings; crucible outfits, bench tools and other types of modern machinery for producing and handling a large output to the best advantage. Until recently there has probably been no branch of the metal trades industry in which so little was done, as in founding, to assist the skill of the workmen by mechanical appliances; but this condition is rapidly changing and The Falk Company has been one of the pioneers in bringing about an improvement.

To properly clean castings is as essential as to properly mold them, and the facilities afforded here for this work are of the best. After the castings have cooled they are taken by cranes, if large, or on rail-tracks, if small, directly to the cleaning department, which is an 80-ft. integral extension of the main foundry, 155 feet wide, and is fitted throughout with pneumatic devices, such as hoists, chipping hammers, sand blasts, surface-grinders of the swing frame type built by the Safety Emery Wheel Company and saws of various sizes capable of removing heads ranging from those of the smallest dimensions to weights of two to three tons or more. At one end is a sand blast room

with an exhaust fan in the side to draw off the flying dust. Compressed air for this and the other departments is brought in direct pipes from a main duct which runs to the center of the foundry in a straight line from the power plant. In this connection it is of interest to note that The Falk Company has obtained particularly economical results in the production of air by means of two-stage compression. The single stage



FIG. 1.—OPEN-HEARTH FURNACES AT FALK CO. PLANT.

machine in the power plant is only used as an auxiliary. Both are of Allis-Chalmers Company's build.

Waste is, of course, carefully looked after. All of the spruce and overplus, are collected each night, if not oftener, and taken directly to the scrap piles in the yard to be melted over again with pig.

Adjacent to the foundry and served by a 20-ton crane built by the Industrial Works, Bay City, Mich., are two annealing furnaces especially designed and built by The Falk Company, of sufficient size to admit the largest castings and so constructed as to obtain an evenly applied heat throughout, thus assuring uniformity in the texture and general quality of the castings. The tops of the trucks upon which castings are run in to the furnace form the principal part of the floor. By means of constant experiments and tests the annealing in these furnaces is kept at a high state of efficiency.

The floor of the foundry is lighted in the day time by side windows and a monitor extending the entire length of the building, which has ventilator windows on each side. At night,



FIG. 2.—STOCK ROOM.

arc lamp illumination is used. The height of the building is such as to give ample space for the gas, smoke and steam to rise and pass off through the ventilators.

The shops are heated in winter by means of the National Blower Company's system, which consists of forcing hot air through pipes running along the top of the building.

Sand is kept in sufficient supply to dry naturally before being

used and it is carefully selected and mixed, the grades adapted to each class of work being kept separate. Temporary storage bins are placed at one end of the molding room and the main supply kept under cover in a frame structure near the railroad tracks, where brick and furnace linings are also kept.

Unusually successful results have been obtained here by the use of electric welding, which, only a few years ago, was regarded with suspicion. Bars welded by this method have stood tests of tensile strength on a Riehle testing machine (Fig. 3) up to 58,000 lb. per sq. in. This, however, is not necessarily indigenous to the system itself, which like any other system of welding, is capable of misuse, but has been brought about by constant experiment and observation of working results.

From one to another of the various operations the work is so laid out and arranged that every man does just what he has been employed to do; for example, molders actually mold and do not perform such operations as pulling out castings, taking care of the bottom boards, wetting down the sand, "cutting-over," etc., which can be done just as readily by assistants or laborers whose pay is much less. The molders are also relieved

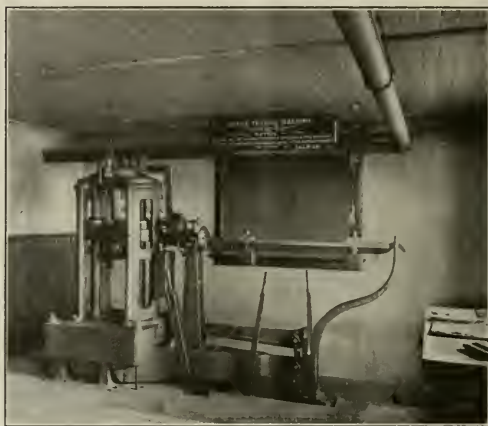


FIG. 3.—RIEHLE TESTING MACHINE (200,000 LB. CAPACITY).

from participating in or superintending the pouring, there being a special pouring gang for this purpose.

As a necessary adjunct to the foundry, The Falk Company maintains its own chemical testing laboratories, which, like all the plant, are thoroughly modern in equipment.

The testing laboratory has a Riehle testing machine of 100 tons capacity, a LaChatelier pyrometer, a Siemens water pyrometer, and a full set of microphotographic apparatus. This enables The Falk Company to secure a complete and minute record, physical and chemical, of all material used in the furnaces and of the resultant castings.

At one side of the works is an emergency hospital, where immediate surgical and medical aid can be rendered in case of accident.

Patterns.

Lumber for use in the pattern shop is thoroughly seasoned and a large quantity kept constantly on hand, as the importance of using material in the proper condition for castings, thereby insuring against shrinkage or distortion, is not to be overestimated in steel foundry practice.

The Falk Company makes a specialty of turning out patterns for customers, particularly for duplicate work or that of an intricate nature requiring special care in shrinkage measurements.

All patterns made in The Falk works or received from the outside are carefully numbered and placed in a steel-frame con-

crete pattern storage building, well arranged with shelves and partitions, where a card record of them is kept. A very elaborate system has been evolved for keeping orders and checking up daily all the work done, and a complete card index of the patterns is kept.

The pattern shop is equipped with wood working machinery of the latest type, the principal part of which was furnished by



FIG. 4.—LARGE STEEL SPROCKET WHEEL MADE BY FALK CO. FOR ALLIS-CHALMERS CO.

the Oliver Machinery Company, together with the Fox Machine Company, both of Grand Rapids, the Security Machine Company of Chicago, and the Rowley-Hernance Company of Williamsport, Pa. A very interesting tool used in this department is also one for cutting gear pattern teeth, which is built by The Falk Company itself.

Railway Department.

The railway department of The Falk Company, which now serves street and interurban traction companies, as well as steam roads, turns out cast steel gears and forged steel pinions; girder rail and high T sections for city railways; low standard sections of from 56 to 100 pounds for steam and interurban lines, and a great variety of special work. This department has an exceedingly well-equipped machine shop, including planers and lathes furnished by the Niles-Bement-Pond Co. of New York, the American Machine Tool Company and the Lodge & Shipley Machine Tool Co. of Cincinnati; drilling and boring machines of the type manufactured by Pawling & Harnischfeger of Milwaukee; gear cutters of Gould & Eberhardt of Newark, N. J.; drills of Prentice Bros. Co. of Worcester, Mass.; Bryant milling saws of Henry Disston & Sons, of Philadelphia; key seaters of Mitts & Merrill, Saginaw, Mich.; milling machines built by the Kempsmith Mfg. Co., and Kearney & Trecker Co., both of Milwaukee, the former having special feed changing and tripping mechanism; boring mills of the Colburn Machine Tool Co. of Franklin, Pa.; draw cut shapers of the Morton Mfg. Co. of Muskegon Heights, Mich.; grinders of the Brown & Sharpe Mfg. Co. of Providence, R. I., and of the

Safety Emery Wheel Co. of Springfield, Ohio; rail saws furnished by the Railroad Supply Co. of Chicago; expansible reamers of a new type, designed and built by The Falk Company; hydraulic presses, with accumulator and pump built by Logemann Bros. of Milwaukee, the latter direct-driven by an Allis-Chalmers type "K" motor, and some very efficient and accurate pinion cutters of The Falk Company's own manufacture.

In the forge shop are three steam hammers built by the Niles-Bement-Pond Company of New York, two of 1500 lb. and one of 1000 lb. capacity, together with blowers and forges of the Buffalo Forge Company of Buffalo and a full complement of forging tools. The heating furnaces are of standard design. In this shop are produced monthly thousands of forged blanks for street railway motor pinions.

The most popular types of frogs, switches, etc., made by the company for street railway service are the hardened center manganese insert and the solid cast steel types. The special feature of the former is the binding of the separate parts together with the plates by a mass of open-hearth steel, producing an integral structure. This feature is also carried out in the construction of hardened center railroad crossings. All wearing points and surfaces, such as frog and mate points, with running surfaces in their proximity and near the points of tongues, are

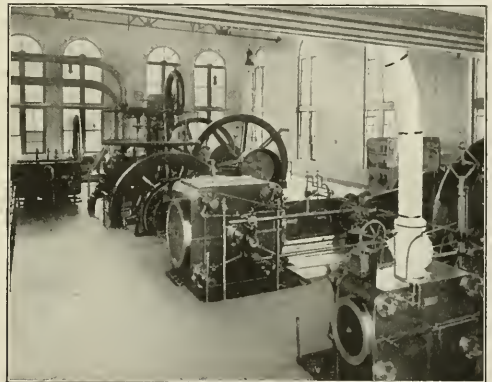


FIG. 5.—PART OF POWER PLANT OF FALK CO.

especially hardened by The Falk Company's own process, and, being integral with the main casting, there are no parts to become loose.

The steel-bound-integral type of construction is also now being largely turned out by The Falk Company. This overcomes the objection to the bolted construction by eliminating all loose parts. The individual pieces are firmly bound together by a steel casting, which, in frogs, is so designed as to give protection to the frog points. The use of steel of high carbon and manganese composition insures a durability not obtainable with the gray iron ordinarily used. To small and growing systems, not desiring to purchase the more expensive high-grade hardened center work, but wishing for something better than the built-up type, the steel bound fills the want. However, built-up "regular" special work still holds its own with the smaller lines and the system which, being a fast-growing one, requires constant changes by reason of increased traffic, new extensions and consequent re-routing of lines of operation.

One feature of The Falk Company's railway work, which is now so well known as not to require extended mention, is that of cast welded joints for lengthening the life of old rails.

Power.

All of the machinery in the entire works of the company, which does not take compressed air, is electrically operated, principally by individual motor-drive, although short lines of

shutting are used in such places as the pattern shop, cleaning department of the foundry, etc., where numbers of light running machines make this arrangement the most advantageous. Electric current and compressed air are supplied from a new central power station which is one of the most interesting features of The Falk Company's works. Neatness, orderly arrangement and absence of a large percentage of the usual quantity of piping, are points which strike the visitor's attention immediately upon entering; but, as the station design is followed out it soon becomes apparent that these are only an index to the general character of the plant, which was equipped, in all its main details—engines, generator, compressors, circulating pumps, etc.—by the Allis-Chalmers Company, of Milwaukee.

The machinery consists of a cross-compound condensing Reynolds-Corliss engine, operating at 100 r.p.m. and coupled to a 550-kw generator, delivering direct current at 250 volts; a simple condensing Reynolds-Corliss engine of the vertical pattern, direct connected to a 125-kw generator with characteristics similar to the larger machine; and two air compressors, one two-stage and the other single-stage, having capacities of 2500 and 1800 cu. ft. of air per minute.

In the steam generating room are three Wickes vertical water-tube boilers designed for a working pressure of 150 lb. and rated at 300 hp each, with furnaces and grates of the same builders' standard construction.

The switchboard was built by Geo. F. Rohn, of Milwaukee, and equipped with standard apparatus, including the Cutler-Hammer switches. The distribution of current to the shops is through insulated underground cables, which feed a network of wires run in iron piping to the various departments where power is needed.

The plant is thoroughly equipped with modern appliances for conducting efficiency tests and gathering daily records, all of which are kept in constant service, and this has a very appreciable effect upon the operating economy.

As The Falk Company started at its present site in 1899 with a plant extending over less than a quarter of an acre, and the present works have now an area of 50 acres, including a covered floor space of nearly ten acres, it is apparent that conditions leading to the rapid expansion of the business must have been uncommonly favorable. Among these the principal one is undoubtedly the management of the works themselves, an interesting feature of which is the treatment of the employees and their relation to the officers and heads of departments. All of the men in the plant, including not only those who occupy responsible positions, but also the great majority of the skilled pattern makers, molders and laborers, have been trained here to the positions which they now occupy. It is a recognized principle, well exemplified here, that to successfully handle men those in authority must be leaders rather than drivers. The plant is run strictly as a non-union shop; consequently there is no check upon individual ambition and ability.

In the office building, which is a two-story pressed-brick structure fronting the works, the same system and good order are observable as in the shops. One very interesting detail of The Falk Company's organization is its purchasing system, which has here been literally "reduced to a science."

The Falk Company's reputation as steel founders is now widely diffused through the country. It has demonstrated its ability to produce satisfactory castings, not only of a general character, but also those of the most difficult kind, some of which other foundries have failed to make successfully. In this way it has established itself with the largest and most particular users of steel castings in America, and the business is now operated upon a basis which cannot fail to make for continued prosperity in the future.

The officers are Herman W. Falk, president; Otto H. Falk, vice-president; Charles L. Jones, second vice-president; E. A. Wurster, secretary and treasurer; Clarence R. Falk, works manager; Harold Falk, general superintendent, and W. Frank Carr, chief engineer.

The Girod Electric Steel Furnace.

In our January issue, 1907 (our vol. V, p. 9), Dr. R. S. Hutton gave an interesting review of the activity of the Société Anonyme Electrometallurgique, Procédés Paul Girod, which has three important works in operation in Europe, viz., at Ugine in Savoy, at Courtepin and at Montbovon, in Switzerland. The magnitude of these works is indicated by the following figures of the annual output; 5000 tons ferrosilicon of 50 per cent, 1000 tons ferrosilicon of 30 per cent, 2000 tons ferrochromium, 800 to 900 tons ferrotungsten, and smaller quantities of ferromolybdenum and ferrovanadium. The rapidity of the growth of this industry is evident from the fact that M. Paul Girod started in 1898 with a small experimental plant of only 28 hp.

After this splendid commercial success of M. Girod in the manufacture of ferroalloys, he naturally turned his attention to steel making and refining. Early experiments were made with a furnace, consisting of a refractory crucible embedded in granular carbon which acted as resistor (described and illustrated in our vol. II, p. 309). The furnace was, therefore, a plain resistance furnace and the method of operation was essentially that of the crucible process, the only novel feature being the heating of the crucible electrically by means of a carbon resistor. Naturally M. Girod could make in this furnace high-grade steel of crucible-steel quality, but he recognized soon that this type of furnace did not exhaust the economical possibilities of electric steel making. As noticed in Dr. Hutton's article, this type of furnace was, therefore, abandoned for steel manufacture and M. Girod turned his attention to the development of a furnace which would combine arc and resistance heating, and in which the steel bath itself would form the resistor.

The advantages of the arc furnace for steel making are well known from the process of Dr. Héroult in which two carbon electrodes are used above the slag which covers the steel bath. The arcs play between the ends of the carbons and the slag and the two arcs are in series, the two carbons being of opposite polarity. The electric current passes from one carbon into the slag, and through slag and metal bath, and out of it into the other electrode. The furnace is essentially an arc furnace. Almost the whole heat comes from the arc, only a few per cent of the total heat being Joulean heat.

While the new Girod furnace is similar in external appearance, it is essentially different in so far as the carbon electrodes at the top are all of the same polarity, whatever their number, while the other pole is provided in the bottom of the furnace. All the electrodes at the top are therefore in parallel. The electric current passes from these electrodes into the slag, then into the steel bath, and leaves through the bottom. The slag and the steel bath represent two resistances in series and the furnace is a combined arc and resistance furnace. Naturally it is not necessary that there are two electrodes at the top. For furnaces of small size one electrode is sufficient.

The fact that there is only one arc on top of the bath (or several in parallel, but not in series) has the following advantages. It permits easier automatic regulation, because the difficulties of regulating two arcs in series are overcome. Further, the voltage is reduced to one-half that required with two arcs; the Girod furnace is operated practically at 50 volts. This results in a very easy method of providing thorough insulation and greatly reduces the risks to workmen. Naturally for the same power, the conductors to the furnace have now to carry a correspondingly increased current and must therefore be made thicker. The fact that the whole current must pass through the charge, facilitates greatly the starting with cold charges.

The furnace is formed by a sheet-steel framework of circular or rectangular section, lined with magnesia. A charging and working door, and also a top hole, are provided in the walls. The steel is tapped by tilting the furnace, which is therefore mounted on pivots or on a cradle.

The roof is made from silicon brick built around cast-iron

pieces with inside independent water circulation, through which pass the electrodes. The electrodes are adjusted in such a manner that the air cannot enter into the furnace; this adjustment, and the use of the cast-iron parts, are rendered possible by the fact that there are no electrodes of different polarity at the top so that there is no danger of a short circuit through the cover.

The automatic regulation of the electrode is either voltage regulation or current regulation. For furnaces of small capacity, say 2 tons, only one electrode is used at the top; if such a furnace is supplied with energy directly from a generator, voltage regulation is employed; i. e., the regulating mechanism tends to keep the voltage constant. If the furnace is supplied

with energy from a transformer or if there are several electrodes (in parallel) at the top, current regulation is used, i. e., the regulating mechanism tends to keep the current constant.

The steel bath reaches a height of from 25 to 30 cm in the bath. As explained before, the bottom of the hearth acts as an electrode. For this purpose several soft-steel blocks are embedded in the hearth and are in direct contact with the molten metal. Of course, there is a tendency of the upper parts of these lower pole pieces to become molten at their extreme ends. But practice has shown that they do not decrease by more than 5 or 10 cm in length in several months' work. With a view to counteracting this tendency and preserving the lower lining of the furnace intact, the extreme lower end of the pole pieces are water-cooled. A cavity about 150 mm deep is provided for this purpose in that part of the piece which projects outside of the furnace frame; this projection is also connected with the external circuit.

The process of steel making and refining in the Girod furnace is in its metallurgical aspects quite similar to electric steel treatment in general. A period of decarbonizing with oxidizing slags is followed by removal of phosphorus and sulphur by

means of basic slags and recarburization to the desired degree. This subject is discussed at great length in an article on the removal of sulphur in electric steel furnaces, published elsewhere in this issue.

The consumption of power per ton of steel produced is from 800 to 900 kw-hours at the terminals of the furnace; therefore, allowing for 10 per cent loss in the conduits, a consumption of about 1000 kw-hours per ton at the generator can be reckoned on, it being understood that a steel of superior quality is being

produced from unsorted iron and steel scrap of the cheapest kind.

In the case of merely smelting a charge of a given composition as in the crucible furnace, the consumption may vary between 650 and 750 kw-hours, but then the extra cost of the raw materials exceeds the saving in power. The final composition of the steel likewise plays an important part in the number of kilowatt-hours consumed per ton.

These figures of consumption were obtained in the operation of the Uginé furnace of 275 kw, which has a capacity of 1800 kg. In furnaces with a greater capacity the consumption in kilowatt-hours per ton of steel smelted and refined or only melted diminishes to a considerable extent.

Should liquid steel from a Martin or Bessemer furnace be charged into the electric furnace it would be necessary to expend 350 kw-hours per ton for refining and giving the exact quality to the metal in the 1800 kw electric furnace. This consumption may be diminished to about 250 or 300 kw-hours, according to the capacity of the furnace and the nature of the product to be refined and obtained.

The cost for consumption of the electrodes when starting with scrap as raw material amounts to about 5 francs (one dollar) per ton of steel produced. When refining a liquid charge, it becomes as low as 2 francs (40 cents) per ton of steel.

For the management of a 3-ton furnace a melter, an assistant and a boy are necessary.

The adjoining illustration gives the drawings of a 2-ton 300-kw furnace, with only one electrode at the top. Furnaces of larger capacity are provided with more than one electrode at the top, all being in parallel.

Messrs. C. W. Leavitt & Co., of New York, are the representatives of M. Girod in this country.

A New Electric Pyrometer.

A new electric pyrometer has been placed on the market by Edward Brown & Son, 309 Walnut Street, Philadelphia, Pa. which approaches the accuracy of the Le Chatelier pyrometer, but which can be subjected to the roughest kind of usage and can be supplied at a moderate price.

The Brown electric pyrometer consists, in the stationary form, Fig. 1, of a large-size switchboard type millivoltmeter for indicating the temperature, a thermocouple which is inserted in the furnace the temperature of which is to be measured, and the



FIG. 1.—STATIONARY TYPE OF INDICATOR.

leads or wiring for connecting the thermocouple to the indicator, which may have practically any length desired. The extra large millivoltmeter used with this instrument is particularly desirable, as the scale graduated in temperature degrees is exceptionally long with large figures, which can be easily read at a distance by a workman. Where a portable instrument is re-

quired, which can be readily carried about, a portable indicator is supplied, such as illustrated in Fig. 2.

The thermocouple is part of the pyrometer which is inserted in the furnace or other room, the temperature of which is to be measured.

For measuring most temperatures which are not excessive, the thermocouple is constructed of heavy nickel alloy and tungsten alloy wires, having a fusing point of 2700° Fahr.

This form of couple is, however, not recommended for tem-



FIG. 2.—PORTABLE PYROMETER WITH THERMOCOUPLE.

peratures as high as this, the platinum-rhodium thermocouple being much more durable and constant in its indication at such high temperatures.

The wires of the thermocouple are insulated by small fire-

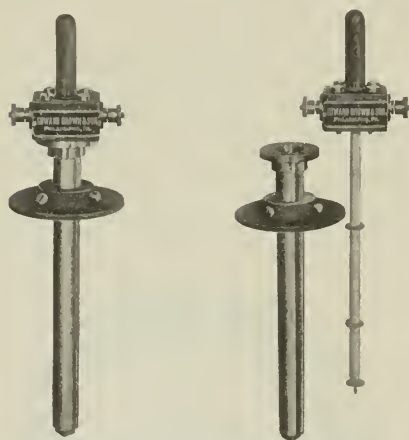


FIG. 3.—THERMOCOUPLE IN STEEL TUBE AND ADJUSTABLE FLANGE. FIG. 4.—THERMOCOUPLE AND STEEL TUBE PROTECTOR.

clay tubes and mica washers, serving to hold the wires in the center of the protecting tube.

The great advantage of this insulation is that it will stand 3000° Fahr. or 1600° C. without damage, and is besides quite inexpensive.

For protecting the thermocouple, steel tubes are used in most cases up to 1600° Fahr., while for temperatures above this tubes of porcelain, quartz, firebrick and graphite are preferable, and each form of tube has its advantages for certain uses.

Where instantaneous temperature measurements are required as is the case with molten metals, an unprotected thermocouple is supplied, heavy in construction, and especially designed for quick readings.

A very advantageous feature of the electric pyrometer is in the ability to connect a number of thermocouples to one indi-

cator by means of a switchboard. By turning the handle of a switch to any of several numbered points, the temperature of any of the furnaces or metal baths, correspondingly numbered, can be read off on the indicator. The switchboard, supplied with the Brown electric pyrometer, works on the knife-switch principle, which is absolutely positive in its action and with which poor contacts cannot occur. It has the advantage over the knife switch in that only one handle has to be turned to any of the numbered points, and it is impossible for more than one thermocouple to be thrown onto the indicator at a time, which could readily occur with a number of knife switches in a row.

In blast furnace practice, a thermocouple especially designed for this use, is inserted in the bustle pipe, also one in the top of the dust-catcher for gas temperatures, and these can either be connected to individual indicators or to one indicator with a switchboard, and a recorder can also be connected to the same couples to record the temperature in the superintendent's office.

This pyrometer has also proven very desirable at blast furnaces with iron stoves, one couple being used for each stove, one on the bustle pipe and one on the dust-catcher, and all connected to a switchboard and indicator.

In annealing, hardening, tempering, etc., the pyrometer has proven of the greatest advantage whether this is done in coal,



FIG. 5.—COMPLETE INSTALLATION OF ANNEALING OVENS, SHOWING OVENS IN THE DISTANCE.

oil or gas-fired furnaces, or in metal baths using lead, barium chloride or any other salt.

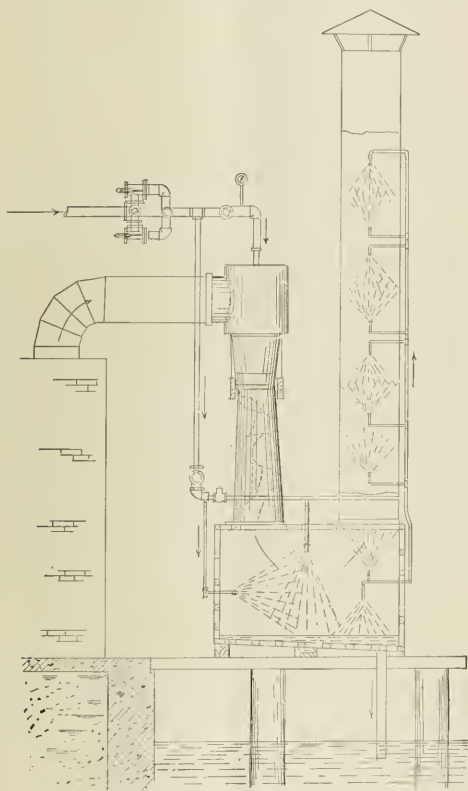
Tinning and galvanizing require very accurate temperature measuring instruments, and with this pyrometer so tinning pots can be connected to a switchboard and indicator in the superintendent's office at very moderate cost. He can thus find out the temperature of every pot in the tin house in a few minutes and without leaving his office.

In glass works probably the highest temperatures are met for any great length of time, and the Brown electric pyrometer is at present in use, week in, week out, on glass-melting tank furnaces at 2750° Fahr. When checked up with a portable Le Chatelier pyrometer no error has been found in their readings. A pyrometer which will stand such severe conditions is naturally very desirable for measuring the ordinary temperatures usually found in ordinary industrial works, where a practical pyrometer is needed of low first cost and little expense for maintenance when placed in the hands of the workingmen.

Mercury Mine.

The Black Butte quicksilver mine in Lane County, Oregon, 150 miles south of Portland, is one of the most extensively developed mercury mines of the present day in the United States. The vein is 400 feet wide, and has been opened for over a mile along its course and down to a depth of 1600 feet below the apex of the mountain. There are more than 16,000 feet, or over three miles, of tunnels, raises, etc.

The mine is of principal interest, however, on account of the distillation process employed, which is a new departure in metallurgy. Mr. W. B. Dennis, the manager of the mine, is the inventor. Since the process was described in detail in our Vol. IV, page 463, we will repeat here only the essential features.



VAPOR EXHAUSTION AND ABSORPTION PLANT.

The fuel gas (producer gas) passes through the roasting furnace in the same direction as the ore is moved. The whole furnace is divided into a number of zones, and the temperature slope between the ore and heat current in each zone is adjusted and regulated according to the special conditions of each zone. The fuel gas made in the gas producer is not supplied in bulk at once at the cold end of the furnace, but is gradually supplied to each zone, together with enough air, according to the conditions prevailing in each zone.

Compared with the old-type mercury-ore roasting furnaces, the Dennis furnace is stated to have shown the following principal advantages in a long series of tests:

Reduction of the roasting period from 36 to 4 hours.

Increase of capacity over the old types of furnaces in the ratio of 6 to 1.

Complete elimination of all soot and smoke, thereby putting a stop to losses through the smokestack, and doing away with the expense and incident loss of re-handling condenser products.

Entire elimination of all danger to workmen, and of the detrimental effect upon the surrounding country from escaping smokestack gases.

Clear running quicksilver in the condensers and very greatly increased ratio of recovery.

The entire elimination of all values from the flue dust and therefore of the losses and expense of re-handling dust chamber products common to other types of furnaces.

Complete reduction of all values in one operation, with no residue from any portion of the process requiring re-treatment.

Vapor Condenser.

The Schutte & Koerting Company, of Philadelphia, have developed a new vapor condensing outfit for eliminating the smell in fertilizer plants, packing houses, etc., especially in connection with driers where the fertilizer material is treated. The great advantage of this system, which is proving very satisfactory in practice, is that the force of the water creating the draft in the water-jet exhauster is utilized at the same time to condense the vapors; in that way one of the operations is free to the user. The plant which is shown in the adjoining diagram works in the following way:

The water-jet exhauster working with water pressure of 80 lb. creates a vacuum and sucks the vapors from the drier, or from a room where the obnoxious gases are, and presses them through a scrubber to the atmosphere. The scrubber is equipped with spray nozzles of the Koerting centrifugal type, which take care of the rest of the fumes which might have passed the exhauster. The arrangement not only takes care of the odors and eliminates the same, but also increases the output of the drier on account of the draft created.

The Schutte & Koerting Company have installed a number of plants to entire satisfaction, for instance, I. P. Thomas & Company, Paulsboro, N. J., and the Alpha Process Company, Wilmington, Del., and are now installing one for the Seacoast Canning Company, Eastport, Maine, and A. W. Dodd & Company, Gloucester, Mass.

Oxygenite and Its Use in Antogenous Welding.

We have had occasion to refer repeatedly to the pioneer work of the Industrial Oxygen Company, of New York City, in introducing to this country the process of antogenous welding by means of the oxy-acetylene flame. It is now being generally recognized that a welded joint is in every respect superior to a riveted joint. Further, the Industrial Oxygen Company has so perfected all the details of the oxy-acetylene blow-pipe and accessories that an ordinary workman is easily able to do efficient welding work with but little practice.

To meet the requirement of producing oxygen gas at the spot where and when needed, this company has now placed on the market a new product called oxygenite. "Oxygenite is a special product in powder form, somewhat resembling fine gray sand; possessing the remarkable property of liberating the oxygen it contains when burned in a closed vessel; giving off about five cubic feet per pound, and at the same time storing itself under a pressure of from 150 to 200 pounds, according to the capacity of apparatus used, without the aid of auxiliary compressor or power. It is practically impervious to moisture, and therefore does not deteriorate to any extent, even from constant atmospheric exposure."

The welding plant comprises apparatus for generating both oxygen and acetylene and bringing the gases to the blow-pipes at any desired location in such a manner that exact regulation of the flame may be easily obtained by the workman.

In the case of oxygen it is necessary to have a reserve under a pressure of from 100 to 200 lbs. per square inch. The oxygen

when produced in the oxygen generator is passed through a washing and cooling device and then to the storage tank, which is fitted with the necessary gauges and valves. Acetylene is not used under a high pressure in the apparatus, it being only necessary to use a pressure of not exceeding 2 lbs. per sq. in., sufficient to ensure a constant flow of gas from generator to blow-pipe.

The charging of the oxygen generator with oxygenite does not take more than three minutes, while the generation of the oxygen gas takes from 20 to 40 minutes, according to the size of the charge. Any quantity of oxygenite, from 12 lbs. upward, liberates about 5 cu. ft. per lb. The acetylene is generated in a specially designed generator, which is specially designed and adapted for welding purposes.

A complete set of nozzles, 34 in number, is furnished by the Industrial Oxygen Company with each blow-pipe, enabling the

for cutting plates. It consists of an ordinary blow-pipe (for preheating the plate to the desired high temperature) combined with an additional oxygen-supply pipe through which a stream of oxygen is directed on the heated portion of the plate. The process has very decided advantages and should have a great future in this country. It is being used now to a large extent in Continental Europe.

Notes.

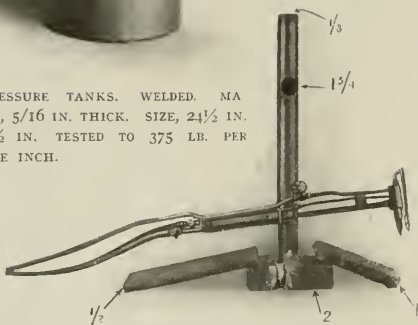
American Electrochemical Society.—At the August meeting of the board of directors, Dr. C. Schall, of the University of Leipzig, Germany, and Mr. Leonard C. Morgan, of the United States Mint, Philadelphia, were elected members of the society. At the September meeting the names of not less than 61 gentlemen will be presented for election. They are: Messrs Oscar F. Stevens, New York; James T. Hutchings, Rochester, N. Y.; F. W. Schiller, New York; John D. Hilliard, Albany, N. Y.; L. K. Comstock, Upper Montclair, N. J.; Langdon Albright, Buffalo, N. Y.; C. W. Parkhurst, Johnstown, Pa.; Robert Stuart Stewart, Detroit, Mich.; R. W. Stovel, New York; Clifton R. Hayes, Fitchburg, Mass.; L. W. Webb, Norfolk, Va.; Albert O. Bencke, Newark, N. J.; Thomas H. Yawger, Rochester, N. Y.; Sherman Coke Lloyd, Wilmington, Del.; John L. Yardley, Buffalo, N. Y.; Otto Kney, Madison, Wis.; Henry G. Reist, Schenectady, N. Y.; J. Franklin Stevens, Philadelphia, Pa.; L. H. Lathrop, Milwaukee, Wis.; William Hoopes, Pittsburg, Pa.; Albert Rockenhacher, Washington, D. C.; William N. Dickinson, New York; F. H. Willard, Rochester, N. Y.; Harry Le Vague Wills, Savannah, Ga.; J. Stanley Richmond, Toronto, Ont., Can.; Clarence D. Fitts, Oakville, Conn.; Jonathan W. Harris, New York; William J. Lansley, Perth Amboy, N. J.; Carleton A. Graves, Brooklyn, N. Y.; Ernest L. Doty, Buffalo, N. Y.; David J. Block, Chicago, Ill.; Edward E. Cary, New York; Joseph N. G. Nesbitt, Atlanta, Ga.; Edward Heitmann, Ampere, N. J.; Albert E. Peirce, Eau Clair, Wis.; James Joseph Dorney, St. Louis, Mo.; Leland L. Summers, Chicago, Ill.; Fred M. Sturgess, Pittsburg, Pa.; Lucius F. Hallett, Denver, Col.; John H. Ballweg, Baker City, Ore.; John B. Whitehead, Baltimore, Md.; C. J. Stro-sacker, Midland, Mich.; Charles J. Adsit, Warren, Ariz.; J. Frank Howard, Jersey Shore, Pa.; Thomas F. Judge, Woodland, Me.; Eugene H. Abadie, St. Louis, Mo.; Frank Davis Morgans, Columbus, Ohio; William S. Develin, New Castle, Pa.; Edwin S. Lincoln, Brookline, Mass.; M. Philip Sheridan, La Luz, Guanajuato, Mexico; Lloyd E. Knapp, Dallas, Tex.; E. M. Wilkins, San Luis Potosi, San Luis Potosi, Mexico; Frederick J. Neuman, Chicago, Ill.; A. H. Wellensiek, Aberdeen, S. D.; Arthur Williams, St. Louis, Mo.; W. L. Emery, Salt Lake City, Utah; Arthur T. Beasley, Coalinga, Cal.; Thomas E. Dainels, Richmond, Utah; Alanson N. Topping, Lafayette, Ind.; Camilo C. Cito, Irvington, N. J.; Eddie Collingwood Creagh, Old Trafford, Manchester, England.

Dry Blast.—The Gayley dry-blast process, which was first tried on the Isabella Furnaces of the Carnegie Steel Company, in Pittsburg, with the well-known extraordinary results, is now extending its sphere of usefulness throughout the country. It has given excellent results at the Warwick Iron & Steel Company, at Pottstown, Pa. (see our January issue, page 12), at the South Chicago furnaces of the Illinois Steel Company, and at the Cardiff furnaces in Wales. Licenses for new installations of the Gayley process for blast furnaces have been granted to the Toledo Furnace Company, of Toledo, Ohio; the Federal Furnace Company, of Chicago, Ill.; the Northwestern Iron Company, of Mayville, Wis.; the Youngstown Sheet & Tube Company, of Youngstown, Ohio, and the Cleveland-Cliffs Iron Company, of Marquette, Mich. The process has also proven very satisfactory with the Bessemer plant at the South Works of the Illinois Steel Company.

Electric Steel Furnace.—A few editorial remarks in *The Iron Age*, Sept. 3, commenting on a letter in their correspondence



HIGH-PRESSURE TANKS. WELDED. MATERIAL, $\frac{5}{16}$ IN. THICK. SIZE, $2\frac{1}{2}$ IN. X $12\frac{1}{2}$ IN. TESTED TO 375 LB. PER SQUARE INCH.



METAL CUTTING. HOLE CUT IN PIPE. PIECES OF 1-IN. AND 2-IN. STEEL CUT THROUGH.

welder to adapt his blow-pipe to any desired thickness of metal and style of welding. Purchasers have the privilege of free instruction at the company's factory until proficient in the use of the blow-pipe (usually two or three days).

An interesting new development of which the Industrial Oxygen Company has taken hold is the cutting of metal plates by a special blow-pipe. As has been explained before in this journal (see especially the article of M. C. Schoop, our Vol. V, p. 308), the principle of the method is that when a steel plate is heated to a sufficiently high temperature and then a stream of oxygen is directed on the heated spot or line, spontaneous oxidation will take place immediately, resulting in a clean, sharp cut. This principle indicates at once the construction of the special burner

columns on the small Bessemer converter are interesting. They read as follows: "We may add that before many years we expect to see the 'baby' Bessemer completely overshadowed by the electric furnace in the steel foundry."

New York Electrical Show.—Mr. Thomas A. Edison has accepted the presidency of the New York Electrical Show, to be held in Madison Square Garden from Oct. 3 to 14, under the auspices of the large electric supply companies of New York and Brooklyn. Mr. T. C. Martin is the chairman of the advisory board.

Thermometry.—We have received from the Bristol Company, of Waterbury, Conn., their bulletins 91, 92 and 93, which cover all the types of Bristol recording thermometers up to 800° Fahr. The bulletins are interesting with respect to the surprisingly great variety of instruments described.

Electro galvanizing.—We have received from the Meaker Company, of Chicago, a pamphlet entitled "Protection of Iron and Steel From Corrosion." The advantages of providing iron and steel with a protective zinc coating by electrolysis are pointed out, and a description is given of a machine made by the Meaker Company for a continuous galvanizing process. Zinc anodes are used with a special electrolyte, which is stated to give a dense, durable, glossy white deposit without development of hydrogen.

Sherardizing.—The process of sherardizing, invented by Mr. Sherard Cowper-Coles, for covering iron and steel articles with a zinc coating by treatment in contact with zinc dust at an elevated temperature, is now being introduced in this country by the United States Sherardizing Company, of New Castle, Pa. The process was described in detail in illustrated articles of Mr. A. Sang and of Mr. S. Cowper-Coles in our Vol. V, page 187, and in our Vol. VI, page 191, respectively.

Production of Coal.—The United States Geological Survey has just issued the statistical table on the production of coal in the United States from 1814, the date of the earliest record, to the close of 1907. The production has been increasing from year to year, almost without exception. The 100-million short-ton mark was passed in 1882, the 200-million ton mark was passed in 1897, the 300-million ton mark in 1902, and the 400-million ton mark in 1906. The production in 1905, 1906 and 1907 was 392,722,635 tons, 414,157,278 tons and 480,363,424 tons, respectively. The total production in the 94 years from 1814 to 1907 was 6,865,097,567 short tons.

Messrs. Dossert & Company, 242 West Forty-first Street, New York, have received an order for several hundred solderless lugs from the Trumbull Electric Manufacturing Company, of Plainville, Conn., for use on the panel and switchboards to be installed in the new Senate Building, Washington, D. C. The lugs vary greatly in size, and many of them are of special pattern in regard to the contact surface.

Pure Magnesium and Manganese.—We acknowledge receipt of a sample of metallic manganese, free from carbon, 98 to 99 per cent pure, from the Goldschmidt Thermit Company, of New York City. This pure manganese is made by the aluminothermic reaction and is of the greatest value in the brass and bronze industry. Messrs. C. E. Leavitt & Company, New York City, have sent us a sample bar of metallic magnesium over 99 per cent pure. (By a typographical error this was made to read manganese instead of magnesium on page 385, line five, of our last issue. This mistake will have been evident from the note that followed.) The chief use of magnesium is as a deoxidizer in foundry work. Metallic magnesium is made electrolytically.

Trigonometric Slide Rule.—We have received from Mr. M. J. Eichhorn, 5759 Aberdeen Street, Chicago, Ill., a description of his new "trigonometric slide rule," which is not intended to replace the well-known ordinary forms of slide rules, but rather to supplement them. Its special feature is a novel

method of graduation which enables an easy solution of the formula $C^2 = A^2 + B^2 - 2AB \cos c$, which gives the relation between the sides and angles of a triangle. The use of this new slide rule permits a considerable saving of time in solving any numerical problem of plane trigonometry.

The University of Cincinnati, Department of Chemistry, is introducing courses in chemical and metallurgical engineering and would be glad to receive, for their files, catalogues from manufacturers of machinery and appliances used in chemical and metallurgical industries.

The Dover Laboratory, chemists and assayers, of Dover, N. J., have sent us printed price lists for assays and determinations of various metals, coals, coke, limestones and clays. This laboratory was established in 1868, and is now conducted by Mr. Ethelbert Ely.

The Buffalo Foundry & Machine Company, Buffalo, N. Y., who besides making exceptionally large castings, are builders of vacuum drying and impregnating machinery, vacuum drum, shelf and rotary dryers, compressors, pumps, condensers and the Bell steam hammer, recently established a New York office at 143 Liberty Street, with Mr. H. E. Jacoby as resident engineer and manager of New York office.

New Electrolytic Process.—It is reported that work has been started on the erection of a plant of 100 tons capacity at Elkhorn, Mont., to treat tailings, of which there are 125,000 tons on the dump of the Elkhorn Silver Mining Company. The money has been subscribed by Helena people, and all arrangements perfected. The company expects to have the plant completed and in operation within the next few months. This plant will be worked under the Baker-Burwell patents (all of which have been noticed in our columns), and will be the first commercial plant in the United States of its kind. A test plant has been in operation for several months, and the efficiency of the methods demonstrated to the complete satisfaction of the stockholders of the Elkhorn Electrometal Company, which will build the plant under license granted by the Montana Metallurgical Company. The process to be used was described in an American Electrochemical Society paper of Mr. C. E. Baker, published in our Vol. V, page 448.

Personal.

Prof. **Joseph W. Richards**, of Lehigh University, who has spent the last three months in Italy, France and Switzerland, is expected to return in the beginning of October. Dr. Richards will attend the New York meeting of the American Electrochemical Society, of which he is the secretary, and intends to leave again in November for a trip to Europe and Asia.

The many friends of Mr. **George F. Brindley**, who was formerly connected with Mr. H. Y. Castner in England and then for 10 years the works manager of the Niagara Electrochemical Company until he left for Japan in 1906, will be glad to hear that he has returned to this country and is now in San Francisco.

Mr. **H. T. Matthew**, who has been the business manager of ELECTROCHEMICAL and METALLURGICAL INDUSTRY almost from its start in 1902, has accepted the position as Western business manager of *Electrical World*, with headquarters in Chicago. Mr. Matthew is a member of the American Electrochemical Society, and has made a wide acquaintance and won many friends among chemical and metallurgical engineers and manufacturers. We are glad to announce that in his new field of activity Mr. Matthew will continue to represent this journal in the West. Mr. Matthew's successor as business manager of ELECTROCHEMICAL and METALLURGICAL INDUSTRY, with headquarters in New York, is Mr. **J. M. Muir**, who has been connected with the McGraw Publishing Company for a number of years in the advertising departments of the *Street Railway Journal* and *Electrical World*, and has recently been in charge of the business department of the *American Telephone Journal*.

Digest of U. S. Patents.

Compiled by *Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.*
ELECTRIC FURNACES (Continued).

552,341, Dec. 31, 1895, J. A. Vincent and J. E. Hewes, Phila.

Arc type. The lower electrode is a horizontal block, supported in a hinged metal casing and closing the lower end of the furnace-chamber. The upper carbon-block electrode is vertically adjustable in a terra-cotta or fireclay tube by pendulum-controlled clockwork, being gradually and continuously raised in use. The charge is fed into the furnace from hoppers at opposite sides of the tube, by screws. Suitable for production of calcium carbide.

556,626, March 17, 1896, Adam Charles Girard and Ernest Auguste Georges Street, of Paris, France.

Arc type. Heats electrically-conductive materials in the form of bars or rods. The rod, constituting one electrode, is fed longitudinally through a chamber, and one or more arcs are sprung to it from the ends of lateral carbon electrodes. The furnace chamber is a carbon block surrounded, successively, with bricks of carbon, magnesia and fire-clay. The rod is fed by rollers and contact is made therewith by springs. The rod and carbon electrodes may pass through stuffing boxes and gas may be introduced into the chamber under regulated pressure. The rod may be replaced by a tube containing the material to be heated and closed by plugs. In a modified furnace, the rod or tube is fed through aligned openings in the ends of parallel flat carbon bars, an arc being sprung from each to the rod or tube. The arcs may be caused to rotate by a magnetic field.

558,357, April 14, 1896, Michael R. Conley, of Brooklyn, N. Y.
Resistance type. The resistor is a trough-shaped vessel of plumbago and clay, inclined to a taphole at one end and closed by a lid. Three integral lugs project from each side of the vessel, the electric terminals being clamped thereto. Each connection is inclosed and cooled by a ring through which water is circulated, insulated by asbestos.

562,400, June 23, 1896, William R. King and Francis Wyatt, of New York, N. Y.

Arc type. The charge, e. g., for the production of calcium carbide, is fed from a hopper by a screw, through a vertical tube, into the upper end of a depending vertically-adjustable tubular carbon electrode, preferably constituting the anode. An arc is sprung from its lower end to a pan-shaped hearth below.

562,403, June 23, 1896, William R. King and Francis Wyatt, of New York, N. Y.

Resistance type. The furnace chamber is an open-topped structure of brick, having hollow walls filled with a bad conductor of heat and electricity, e. g., a mixture of lime and coke. A fixed carbon electrode projects into the lower end of the chamber and an adjustable carbon electrode depends into the upper end of the chamber. The charge-mixture, equal portions of pulverized coke and ground lime, is shoveled into the chamber, and a rod-core of carbon or coke is forced down through the mass till it touches the lower electrode. The upper electrode is then lowered upon it, lime and coke heaped around the point of contact and direct or alternating current is passed through the core to bring it to incandescence. A nugget of calcium carbide is thus produced, which is pulled out by tongs. The unreduced material falls into the bottom of the chamber and the operation is repeated.

562,404, June 23, 1896, William R. King, of New York, N. Y.

Arc type. The upper electrode consists of six depending carbon plates arranged in a circle to form a tube. Each plate is carried by an independently-adjustable stem. The several stems pass through a vertically-adjustable frame. The lower electrode is a pan-shaped hearth. The charge, e. g., for the manufacture of calcium carbide, is fed into a tube extending centrally into the tube of the central electrode, and thence falls onto a conical spreader.

567,699, September 15, 1896, Joseph A. Vincent, of Phila.

Furnace especially for the production of calcium carbide. The furnace has a vertical chamber with a hearth which recedes as the ingot of carbide or other smelted product increases. The furnace body is of fire-brick, with an upper hopper and feed-screw. Horizontal carbon electrodes, supported on wheeled carriages and electromagnetically controlled, extend through lateral openings, the current passing between them and over the hearth. The hearth may be manipulated by a hydraulic cylinder or a screw. The gases escape by a lateral flue to a stack.

568,184, September 22, 1896, William L. Voelker, of Elizabeth, N. J.

Arc type. The furnace is a pot of calcium oxide, supported in a frame and having a lower opening for delivering the product, as it melts, into a mold below. Lateral electrodes of opposite polarity extend downward through openings in the side walls. The furnace is especially used for melting a mixture of lime and magnesia, with a coloring agent, for the production of materials for incandescent mantels.

569,221, October 13, 1896, Richard G. G. Moldenke, of Pittsburgh, Pa.

Arc type. Metals or alloys to be melted are placed in several pans of the same material, which also melt. Several of these pans, with their contents, are supported in line on an inclined shelf, constituting the hearth of a Siemens regenerative furnace. The charges gradually slide toward the edge of the shelf, where each is subjected to the action of an arc, sprung between converging carbon electrodes and blown inward by an electromagnet. The molten material flows into several crucibles or into a common hearth below. The furnace is used for melting scrap brass, bronze, or steel to which may be added ferrosilicon or ferromanganese.

569,911, October 20, 1896, Levitt E. Custer, of Dayton, Ohio.

Resistance type. Muffle for the manufacture of porcelain dental plates. The muffle is a closed box, having a hinged lid and lined with fire-clay. A tortuous resistance-wire of platinum is partially embedded in the inner faces of the top, bottom and side-walls. An external contact-arm enables sections of the wire to be connected in series or multiple, to furnish different temperatures. The furnace has two small openings in opposite sides, so arranged that a ray of light entering one opening will be reflected by the porcelain object and out through the other opening, thus enabling the temperature to be visually estimated.

NEW BOOKS.

THEORETICAL CHEMISTRY, FROM THE STANDPOINT OF AVOGADRO'S RULE AND THERMODYNAMICS. By Walter Nernst. Rev. in accordance with the fourth German edition. 295 pages. Bound in cloth. Price raised from \$3.75 net to \$4.50 net. New York: Macmillan.

THE DESIGN AND EQUIPMENT OF SMALL CHEMICAL LABORATORIES. By Richard K. Meade, B.S. 136 pages. Bound in cloth. Price, \$2 net. Chicago: The Chemical Engineer Publishing Co.

DESCRIPTIVE GENERAL CHEMISTRY: A TEXT-BOOK FOR SHORT COURSE. By Escut S. Tillman. Fourth edition and enlarged. enlarged. 469 pages. Bound in cloth. Price, \$3 net. New York: John Wiley & Sons.

CHEMISTRY OF GAS MANUFACTURE. By Harold M. Royle. A practical manual for the use of gas engineers, gas managers and students. 343 pages. Bound in cloth. Price, \$4.50. New York: Norman W. Henley & Co.

THE PAPER MILL CHEMIST. By H. P. Stevens. 292 pages; illustrated. Bound in cloth. Price, \$2.50 net. New York: D. Van Nostrand Co.

IRON: ITS SOURCES, PROPERTIES AND MANUFACTURE. By W. H. Greenwood. With numerous engravings and diagrams (revised and partly rewritten by A. Humboldt Sexton). 272 pages; illustrated. 12°. Bound in cloth. Price, \$1. Philadelphia: David McKay.

LATHE DESIGNS FOR HIGH- AND LOW-SPEED STEELS. By T. J. Nicolson and Dempster Smith. A treatise on the kinematical and dynamical principles governing the construction of metal-turning lathes. With notes to guide the purchaser in the choice of a tool and many examples from practice. 414 pages; diagrams. Bound in cloth. Price, \$6. New York: Longmans, Green & Co.

A HANDBOOK OF ROCKS. By Ja. F. Kemp. For use without the microscope; with a glossary of the names of rocks and of other lithological terms. 250 pages; illustrated. Bound in cloth. Price, \$1.50 net. New York: D. Van Nostrand Co.

A TEXT-BOOK OF IMPORTANT MINERALS AND ROCKS; WITH TABLES FOR THE DETERMINATION OF MINERALS. By Escue S. Tillman. Third edition, revised. 187 pages. Bound in cloth. Price, \$2 net. New York: John Wiley & Sons.

GAS POWER. By Franz Erich Junge. A study of the evolution of gas power, the design and construction of large gas engines in Europe, the application of gas power to various industries and the rational utilization of low-grade fuels. 561 pages; diagrams. Bound in cloth. Price, \$5. New York: Hill Publishing Co.

HOW TO USE WATER POWER. By Herbert Chatley. 92 pages; illustrated. Bound in cloth. Price, \$1 net. New York: D. Van Nostrand Co.

NOTES ON HYDRO-ELECTRIC DEVELOPMENTS. By Preston Player. 73 pages. Bound in cloth. Price, \$1 net. New York: McGraw Publishing Co.

HYDRO-ELECTRIC PRACTICE. By H. E. A. C. Von Schon. A practical manual of the development of water power, its conversion to electric energy and its distant transmission. 397 pages; diagrams. Bound in cloth. Price, \$6 net. Philadelphia: Lippincott.

GENERAL LECTURES ON ELECTRICAL ENGINEERING. By C. P. Steinmetz. Edited by Jos. Le Roy Hayden. 275 pages; 48 diagrams. Bound in cloth. Price, \$2 net. Schenectady, N. Y.: Robson & Adee.

HIGH-SPEED DYNAMO-ELECTRIC MACHINERY. By H. Hobart and A. G. Ellis. 545 pages. Bound in cloth. Price, \$6 net. New York: John Wiley & Sons.

THE DYNAMO: ITS THEORY, DESIGN AND MANUFACTURE. By Caesar C. Hawkins and F. Wallis. Fourth edition, with 413 illustrations; 938 pages. Bound in cloth. Price raised from \$3 net to \$3.25 net. New York: Macmillan.

NEW CATECHISM OF ELECTRICITY. By Nehemiah Hawkins. 550 pages; illustrated. Leather binding. Price, \$2. New York: Theodore Audel & Co.

ELEMENTS OF ELECTRICITY AND MAGNETISM: A TEXT-BOOK FOR COLLEGES AND TECHNICAL SCHOOLS. By W. Franklin and Barry MacNutt. 359 pages; diagrams. Bound in cloth. Price, \$1.60 net. New York: Macmillan.

PRACTICAL TREATISE ON THE STEAM ENGINE INDICATOR. By Nehemiah Hawkins. 268 pages. Bound in cloth. Price, \$1. New York: Theodore Audel & Co.

WATER SOFTENING AND PURIFICATION OF HARD AND DIRTY WATERS. By Harold Collet. 177 pages; illustrated. Bound in cloth. Price, \$2. New York: Spon & Chamberlain.

ELEMENTARY LESSONS IN HEAT. By Escue S. Tillman. Fourth edition, revised and enlarged. 196 pages; diagrams 8". Bound in cloth. Price, \$1.50 net. New York: John Wiley & Sons.

CALCULATING TABLES; GIVING THE PRODUCTS OF EVERY TWO NUMBERS FROM 1 TO 1000 AND THEIR APPLICATION TO THE MULTIPLICATION AND DIVISION OF ALL NUMBERS ABOVE 1000. By A. L. Crelle. New edition by O. Seeliger; with tables of the square-numbers and cube-numbers from 1 to 1000. Bound in cloth. Price, \$5. New York: Lemcke & Buechner.

THE PLANE TABLE AND ITS USE IN SURVEYING. By W. H. Lovell. 53 pages. Bound in cloth. Price, \$1 net. New York: McGraw Publishing Co.

BOOK REVIEWS

LEAD AND ZINC IN THE UNITED STATES. By W. R. Ingalls. Editor of the *Engineering and Mining Journal*. Illustrated. Price, \$4.00 net. New York: Hill Publishing Co.

This book is a rather new departure in technical literature, for it is the first to our knowledge that deals with the historical and economic side of the question and only gives such practical information as will help to throw into relief the commercial outlines of the subject. The thought has been often expressed by us in our editorial pages that the modern engineer should above all else know the broad principles of business as well as the broad principles of chemistry and physics in order to direct the new and marvelous forces that are now placed at his disposal. The "*raison d'être*" of Mr. Ingalls's latest work is to fill this much-felt want.

We can thus heartily commend his energy in preparing such a book, amid the cares and responsibilities of editorial life.

Lead and zinc, as every one in the metal trade knows, are almost always associated together in ore deposits, usually in limestone country rocks. The minerals are separated first by some mechanical process as by "jigging" and "tabling." Later other separation processes, such as the electrostatic and the magnetic processes or the flotation process, are used. A great number of different forms of treatment are known and the procedure is to use a combination of processes. Finally, as a general rule, we have three salable products; a lead concentrate, and iron-lead concentrate, and a zinc concentrate. The first goes to the lead smelter as a collector in smelting silicious gold-silver ores, and the second is used as flux in the same operation. The third is sold to a zinc plant. This is the outline treatment of complex ores. Some zinc-lead ores are simple as those of the "Joplin" district and produce simply a high-grade zinc product and a high-grade lead product. In some lead ores as those of the Cœur d'Alene district zinc is present in such forms and percentage as to be neither a serious obstacle nor a by-product.

Lead ores are roasted, for galena is usually now the main commercial mineral. The roasted product is smelted with coke in shaft furnaces to "base bullion." This is desilverized by the Parkes process. Zinc ores are roasted to less than one per cent sulphur and mixed with non-caking carbonaceous material, charged in 50-lb. retorts heated with gas, natural or artificial.

The presence of zinc is detrimental to the lead-smelter and the presence of lead detrimental to the zinc-smelter. The two metals which dwell so harmoniously in the deposits are metallurgically antagonistic and even compete with each other in the paint trade as white lead and zinc white.

The metallurgy of both lead and zinc is far from satisfactory and, especially is the treatment of "complex" ores, wasteful and expensive. Lead smelting is far ahead of its position ten years ago, due to the so-called "pot" roasting and the careful study of slags by the late Septimus Austin.

Mr. Ingalls traces the developments of extracting the metals from the crude beginnings of a pile of wood and stones, the hand jigs of Joplin to the "Scotch" hearth, the magnificent mills treating "sheet" ground in Joplin and the modern smelting plants at Pueblo. He is a careful worker and gleaner of facts and the result is much to be admired. There are, of course, slips, such as the description of the plant of the St. Louis S. & R. Co. as a "Scotch-hearth" plant. To the best of our knowledge, it is a short blast furnace with settling chambers and bag house resembling the Scotch hearth plant only in its use of blast and a filtration. We also believe that it would have been advisable to give a little more of the picturesque history of the pioneer lead smelters. More illustrations would have also redounded to the attractive qualities of the book.

There is one very interesting bit of information to which we have before alluded in our editorial columns. That is the fact that the Cowles brothers bought 25 years ago a zinc-copper-lead mine in New Mexico. They endeavored to perfect an electric

smelting process. This was unsuccessful, but their work with the electric furnace was the beginning of all the electric furnace work of the last decade as well as the reduction of aluminium. Mr. Ingalls errs in the influence of this early work, restricting it to what he calls "aluminium smelting."

We also believe that Mr. Ingalls's habit of quoting so often from his past writings does not lead to a pleasant impression on the reader. It suggests to him that Mr. Ingalls is shirking the work of finding a new expression for his thoughts—which, of course, he is not.

One part of his work that is particularly to be commended is the analysis of the use of a knowledge of trade conditions on the part of the dominating lead company toward the extraction of the maximum monopolistic profit in the lead business both by long ore-contracts and control of the consuming companies' stock instead of by relying on metallurgical efficiency. Comparing the present and future of the American S. & R. Co. with the United States Steel Corporation, we can see that Mr. Ingalls's arraignment is both fair and courageous. To again criticize the book we would state that in our opinion it were wise to analyze fully the consumption of spelter for galvanizing, brass, sheet zinc, etc., and also to add to the rather meagre information given about the consumption of lead.

Summing up, we can state that this book, like all the other works of the author, is much to be admired and should receive much attention from the interested metallurgical public. The book is to form a part of the Economic History of the United States and thanks are due to the Carnegie Institution for its assistance to the publisher and author. We believe it would have been in better taste for the former not to print the names of the several journals which he publishes on the title page of a book which had been prepared with the assistance of an institution whose aims are philanthropic. This gives a commercial coloring to what should be a dignified and high-toned effect. We are sure the author cannot be sponsor for this.

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SYNTHETIC INORGANIC CHEMISTRY. By Arthur A. Blanchard, Ph.D. 12 mo; 89 + viii pages. Cloth. Price, \$1.00 net. New York: John Wiley & Sons.

This book covers a laboratory course for first-year students who have had a general course in the chemistry of the non-metallic elements. The ideas of the author on the subject of the teaching of chemistry of the metallic elements as advanced in the preface should be brought to the attention of all our colleges. The experiments as given for general chemistry are so quickly formed and alike as to awaken no interest in the student. Qualitative analysis is too one-sided for this work, and the only other alternative, the preparation of a number of inorganic reagents and commercial products seems to be the most satisfactory solution of the problem. And with one exception this little book is well adapted to carry out this idea. It gives the object of the exercise, with an outline of the principle of the work involved, followed by exact working directions which if carefully followed will assure satisfactory products, and a series of questions for class-room review.

The exception to the above is the presumption of a knowledge of the dissociation theory and the principle of mass action. Of this latter we might pass over, but it has been the general experience of the reviewer in the teaching of chemical principles to even much more advanced than first-year students that the theory of electrolytic dissociation is a dangerous tool to put into such inexperienced hands. The student on seeing this: "thus if sodium nitrate and potassium chloride are dissolved together in water the resulting solution will contain Na^+ , K^+ , NO_3^- and Cl^- ions" . . . is almost certain to overlook the ionic fact and expect the atomic or even molecular condition instead. To present an idea so easily misconstrued to the student is hardly right. Every reaction mentioned in the book can be completely explained without the use of this theory, which in general is

more a hindrance than a help to the class of men this book is intended to reach.

In general, the arrangement is all that could be desired, and the preparations selected are quite characteristic of both their class of elements and of commercial practice. The book should find a place in the preliminary work of all our courses in general chemistry, it not being intended to supplement the larger works on industrial chemical preparations. An index should have been included, by all means.

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LABORATORIUMSBUCH FÜR DEN METALLHÜTTENCHEMIKER. By H. Nissenson and Dr. W. Pohl. 86 + ix pages. Paper. Price, 3 marks. (Retail price in New York, \$1.00.) Halle a. S., Germany: Wilhelm Knapp.

This, the second volume of the series of laboratory books for the chemical and allied industries, is concerned with the occurrence, qualitative examination and quantitative estimation of the elements aluminium, antimony, arsenic, lead, chromium, gold, cadmium, copper, manganese, molybdenum, nickel, platinum, mercury, silver, thorium, uranium, tungsten, zinc and tin. The book is only intended for the guidance of experienced chemists in the laboratory and not as a text or instruction book for novices.

No claim is made for completeness of schemes, the only ones given being the most reliable of present technical laboratory methods and those in the briefest possible form. Separations are given for some of the elements, more should be given; for instance, that troublesome element zinc is left quite untouched in this regard. Some of the newer methods as the bismutate method for manganese should have found place therein.

The book lacks that very necessary adjunct, an index, though its place is more or less satisfactorily filled with a detailed Table of Contents. The proof-reading for a work of this kind has been most carelessly done, a list of appended corrections not covering half the errors noted by the reviewer.

* * *

THERMODYNAMICS OF TECHNICAL GAS REACTIONS. Seven lectures by Dr. F. Haber, professor at the Institute of Technology in Karlsruhe. Translated by Arthur B. Lamb, Ph.D., director of the Havemeyer Chemical Laboratory, New York City. 356 pages, 20 illustrations. Price, \$3.00. New York: Longmans, Green & Company.

This is an authorized translation of Prof. Haber's noteworthy and highly suggestive "Thermodynamik Technischer Gasreaktionen," which was reviewed in our Vol. IV, page 333.

The English edition is, however, more than a mere translation. It is rather a new edition. Many parts have been rewritten and account has been taken of the progress made during the last few years in chemical thermodynamics. Extensive appendices have been added to three of the lectures; they are of special interest with respect to the standpoint which Haber takes toward *Nernst's* new thermodynamical theorem.

Dr. Lamb, in his preface, sums up the situation very well in these words: "The fascinating possibility of predicting the course of a chemical reaction from a few characteristic constants of the reacting substances seemed very far from realization after the ill-starred attempt of Berthelot. Recent attacks upon this problem have been more successful, and the future is promising."

As we noticed in our former review, the book has been written for the sake of the chemical engineer rather than the theorist. Haber's discussion of such actual engineering problems as the fixation of atmospheric nitrogen or the water-gas reaction, will certainly be found exceedingly interesting and suggestive. However, it is by no means easy reading. It requires not only familiarity of the reader with the chemical and engineering aspects of the subjects discussed, but also some training in higher mathematics.

The translator has done his work well.

Electrochemical and Metallurgical Industry

VOL. VI.

NEW YORK, NOVEMBER, 1908

No. 11.

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the
ELECTROCHEMICAL PUBLISHING COMPANY
239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH. D.....*President*
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Yearly subscription price for United States, Mexico and United States dependencies, \$2.00; for all other countries, \$2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

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New York Meeting of the American Electrochemical Society.

It has become the custom of the American Electrochemical Society to hold every autumn a short meeting in New York City. This year's meeting, the program of which will be found on another page of this issue, will be held on Friday and Saturday, Oct. 30 and 31. The College of the City of New York in its magnificent new home and the ever hospitable Chemists' Club will be the hosts of the Society. That the New York Committee endeavors to make the social functions as enjoyable as ever, goes without saying. A great attraction will prove the excursion on Saturday afternoon to the Balbach Smelting & Refining Works in Newark, as this is the birth-place not only of the Balbach electrolytic process for parting gold and silver, but of electrolytic copper refining in the United States. The process was worked out by Messrs. Edward Balbach, Sr. and Jr., and by Mr. F. A. Thum, and the commercial plant started in 1883, just 25 years ago. It is fitting that at this time the American Electrochemical Society should pay its tribute to the pioneers of copper refining in America. The program of the papers to be read and discussed is also quite attractive. In a general way the morning session of Friday will be devoted to papers of a more scientific character, the afternoon session to a symposium of papers on corrosion of iron and steel and preventives, while a feature of the morning session of Saturday will be a discussion of possible cooperation between central station men and electrochemists as to the utilization of the power at times of low load for electrochemical work. This is an excellent subject and it comes at the right time, since we are now apparently on the eve of resumption of business. We trust that the coming convention will help to inspire in all who attend it that professional esprit de corps which will be needed more than ever, when business activity will again be in full blast, with sharp, but friendly competition.

Finished Steel Products by Electrolysis.

Not so many years ago—say, seven or six—any suggestion on the use of the electric furnace in iron and steel metallurgy was declared to be positively absurd. The stock argument was the proof that on the basis of thermochemical data and with the present price of electrical energy, reduction of iron ore to pig iron in the electric furnace could not possibly compete with the blast furnace. This was a simple and easy enough argument. To speak or to think of the possibilities of the electric furnace for steel refining was too complicated a matter to argue about. But it was right at this point, as the point of least commercial resistance, that the industrial development set in; and it is a matter of some satisfaction to us that the development has proceeded exactly along the lines predicted by us ever since this journal began to make a specialty of this subject early in 1903. The list of electric steel furnaces in Europe alone, published

elsewhere in this issue, proves the absurdity of the arguments of the former critics of the electric steel furnace. In view of this, people should be cautious in speaking rashly of the impossibility of electrolytic processes in iron and steel metallurgy. The problem of reduction of pig iron from iron ore by an electrolytic process (analogous to the reduction of aluminium from alumina, but perhaps with an aqueous solution) seems, of course, hopeless. Not only from the energy standpoint, but because a simple estimate of the reduction plant required shows its first cost to be absolutely prohibitive—if pig iron is to be the final product of electrolysis.

* * *

The process appears in an entirely different light if it should become commercially practical to make steel tubes, sheets, wire from impure iron or iron ore in one or two operations, so as to avoid the processes of melting, rolling, etc., as described in the article of Mr. Cowper-Coles in our present issue. That Mr. Cowper-Coles can produce tubes, sheet, and wire by electrolysis, there is no doubt. The only question is that of cost, and this cannot be settled except by practice. Mr. Edison has been making for years the seamless steel containers for his nickel-iron battery by electrolytic deposition upon a mould. This product has been excellent, and in this case the cost of the electrolytic process may be called low, as the cost of producing this high-grade product by other methods would be much higher. Clearly, the prospects of the electrolytic process are best for the manufacture of special articles like bi-metallic tubing and plates, etc. But it seems safe to say that it will always be necessary to start with a relatively pure anode material in order not to foul the solution. This is the fundamental requirement of any electrolytic process that shall work in practice. The essential new feature of Mr. Cowper-Coles' process is the electrolyte, which is sulpho-cresylic acid. Another line along which electrolytic processes may find useful employment in steel metallurgy in future, is the refining of iron, as by the process of Burgess. The refined iron which is almost chemically pure and contains absolutely no carbon would be a highly valuable raw material for making special ferro-alloys. Here is still an almost unlimited field for research. Iron and steel metallurgy has always been limited to the study of iron-carbon alloys. To determine the possibilities of iron alloys containing no carbon, is a subject that deserves greatest attention.

Estimating the Cost of Experimental Work.

It is always hard to make an accurate engineering estimate of the probable cost of any new installation. The reason for this is that conditions always alter cases, and new and unexpected unfavorable factors are sure to arise, and by the perversity of things usually tend to increase the cost of the work. For instance, in building the concrete foundations of a concentrating mill in the West, it had been assumed that there was plenty of sand in a neighboring dry water-course. However, in the meantime a precipitous rain came and wasted the nearby sand away. Accordingly, it was necessary to haul sand from the valley below with four-horse teams up to the site of the new mill. This added 50 per cent to the cost of the concrete work. So it can be laid down as an axiom that any new plant will exceed the estimated cost unless liberal allowances are made for unexpected expenses.

Naturally, it is much harder to estimate the cost of experimental work, because here the question dealt in is largely expressed in the terms of the unexpected. The experiment is to find out not the expected, but the unexpected. If in a proper estimate of the cost of work along old and well tried methods it is always necessary to include a large item for contingent expenses, how much larger must that be when the field is a new one. While logical guesses can be made, yet it is advisable, if possible, to follow some few rules which appear to govern these guesses. The following suggestion has been given us by an engineer who has spent much time and attention in experimental work. His directions are first to draw up the plans on paper exactly similar to the plans for any plant, allowing, we will say, $4\frac{1}{2}$ cents per pound for the cast iron erected, 6 cents per pound for the steel such as tie-rods and brick-stoves erected, fire-brick at cost plus \$15 per thousand for laying. He then adds what he considers a fair amount for contingent expenses and 20 per cent for the unexpected, just as he would if he were estimating the cost of an old proposition, such as a copper smelter.

* * *

Footing up the totals, he arrives at a figure which would be accurate were the plant a small one, designed for a well-established process like copper-matting. His next step is to multiply this figure by what he terms the "factor of commercial safety for experimental work." This will vary from two and one-half to five, according to the degree of uncertainty. By the use of this method he finds that he usually comes very close to the estimated expense before reaching a final decision pro or con, but only if he uses economy and foresight in his expenditures. But if eternal experimenting is the price of progress, the price should be known as accurately as possible to the weak and poor human. Things are always uncertain in money matters, but it is necessary to introduce some certainty and conservatism, for the foxy and wary capitalist has always the terror of the infant for the dark unknown.

The Evolution of Induction Furnace Design for Steel Refining.

The description, in our present issue, of the Roechling-Rodenhauser three-phase induction furnace emphasizes the peculiar development of induction furnace design leading from the original pure induction type of Colby and Kjellin to the combined induction and electrode type of Roechling and Rodenhauser for single-phase current and finally to the modification of the latter type for three-phase currents. Electrical, mechanical, and metallurgical considerations have determined this evolution. From an electrical viewpoint, the powerfactor has been the chief consideration. The pure induction furnace is essentially a transformer with a fused secondary; and the high temperature of the fused charge which represents the secondary necessitates careful heat insulation from the primary and from the magnetic iron core. On this account not all the lines of magnetic flux encircle both the primary and secondary. Some lines of flux will pass only around one of them and close their path through the available space between primary and secondary. That means, we have a considerable magnetic stray flux; we have self-induction in the two circuits instead of mutual induction. As a result we have a low powerfactor, i. e., a low

ratio of effective watts to volt-amperes. Since the powerfactor is occasionally looked upon by electrochemists and electro-metallurgists as something mysterious and since the question has been asked why it would be such a dreadful thing to have a low powerfactor, a brief explanation of its effects may be given here.

* * *

The power in watts equals directly the product of volts and amperes in every instantaneous moment with single-phase current as well as with direct current. But with our ordinary measuring instruments we do not measure instantaneous values, but effective values, i. e., mean values. Any self-inductance will cause a phase difference between e.m.f. and current, and as a result the product of the instantaneous values of e.m.f. and current will be positive for a part of a period and negative for the balance of the period. In other words, the transport of energy over the single-phase line fluctuates. There is a surging of power, energy being transported in part of one period over the line in one direction and in the balance of the period in the other direction. Only the difference between the two amounts of energy is usefully consumed at the receiving end. But the generators have to supply and the line wires have to carry the total volt-amperes. This will be worse the greater the phase difference, and as the powerfactor may be defined as the cosine of the phase-difference, it is clear that a low powerfactor means a large phase difference and consequently a large surging of power and a comparatively small amount of useful power. The effective watts are no longer equal to the product of effective volts and effective amperes. The ratio of the two is the powerfactor. In other words, the powerfactor is the ratio of the effective power to the ideal amount of power which we would get if there was no phase difference, no surging of power. Hence a low powerfactor means the necessity of using large generators and thick wires. To be more specific, a 50-per-cent powerfactor means the necessity of using conductors of double size, to get the same loss in watts; and it means the necessity of using generators of double capacity, to produce the same useful output. But even so the voltage regulation of the line and of the generators will be poor. It is clear that power companies will object to the use of furnaces having a low powerfactor. On the other hand, if a steel plant generates its own electric power, the use of furnaces with a low powerfactor necessitates an undue increase of the generating capacity of the powerhouse, resulting in increased capital investment and increased cost of operation.

* * *

To reduce the power factor has, therefore, been properly the aim of designers of induction furnaces. One possibility of accomplishing this is to reduce the frequency of the alternating current. But it was soon found that such an unusually low frequency would be necessary for large furnaces as to require special expensive generators. The problem had, therefore, merely been shifted, not solved, as far as large furnaces were required. For smaller furnaces, such as are used for brass, crucible steel, and alloys, the pure induction furnace is quite satisfactory. But for large furnaces the designer was between the devil of a special expensive low-frequency generating plant and the deep sea of a low powerfactor. The solution was to cut the Gordian knot by dropping the pure induction principle and adopting electrodes. The designers of the Roehling-

Rodenhauser furnace do not like to hear their "pole-plates" called electrodes, and the arrangement of their pole-plates and the use of a "conductor of the second class" really means a new departure in electrode construction. Further, they contain no carbon, nor is any regulating mechanism required for these electrodes. The chief point is that on the combination-furnace principle it is now possible to build large furnaces with a satisfactory powerfactor, which can be operated at ordinary commercial frequencies. In this respect the modified induction furnace is no longer at a disadvantage in comparison with other types of electric furnaces.

* * *

The passing of the single-phase furnace and the arrival of the three-phase furnace is interesting in another respect. The three-phase furnace is not entirely new even with steel furnaces. The first Héroult furnace at the Noble plant in California was already built as a three-phase furnace for the reason that the distribution system was three-phase. The same system is used in many steam plants. But even if it is necessary to build a new generating plant, the plant will be cheaper for three-phase furnaces than for single-phase furnaces. As prices of generators now go, it is practically true to say that a 1000-kw single-phase generator costs as much as a three-phase generator which will carry 1000 kw of single-phase load, when only two of its terminals are used. Therefore, if the latter is operated as a three-phase generator, it will furnish power for a correspondingly larger furnace. The cost of three-phase generating plant per kw of furnace capacity is therefore less than the cost of single-phase generating plant.

* * *

However, it would be a narrow viewpoint to look only at the electrical features which have prompted this evolution. Strictly mechanical reasons had undoubtedly much to do with the change from the pure induction furnace to the combined induction and electrode furnace. The narrow, ring-formed channel, containing the charge of the pure induction furnace, offers some difficulties in charging, tapping, cleaning, etc. For relatively small charges, for brass melting, for crucible steel and for alloys, things can be arranged satisfactorily. But for large capacities, as in steel making and refining, the construction of a ring-channel with large volume becomes unwieldy. The large hearth of the new combination furnace solves this difficulty. It also solves nicely some metallurgical problems. If steel is to be refined by means of a very hot slag, it will be very difficult or impossible to get the slag hot enough in a pure induction furnace, because the induced currents will prefer the path of least resistance, i. e., the metal bath. By the special construction of the Roehling-Rodenhauser furnace the current from the pole-plates is forced through the slag. Further, the rotary magnetic field of the three-phase furnace furnishes an excellent automatic circulation of the bath. Finally in the latest designs the object has been to imitate as closely as possible best open-hearth practice. But, after all, one is forced to ask: Is this really the end of this evolution? Why not give up the induction principle altogether, at least, for large capacities? Or, if not altogether, why not connect at least the three pole-plates directly with the transformer or generator, instead of including them in a second secondary circuit? Is not the present design, after all, only a temporary compromise? Qui vivra verra.

New York Meeting of American Electrochemical Society.

The autumn meeting will be held, in accordance with custom, in New York City. The dates are Oct. 30 and 31, Friday and Saturday. The final program is as follows:

The sessions of Oct. 30 will be held at the Chemistry Building, College of the City of New York, in the Doremus Lecture Hall on the second floor. The college buildings are located on Amsterdam Avenue, 138th Street to 140th Street. (Take Broadway train on subway to 137th Street Station, or Ninth Avenue Elevated to 141st Street Station.)

The session of Oct. 31 will be held at the Chemists' Club, 108 West Fifty-fifth Street, New York City. (The Central Park elevated trains on Sixth Avenue to Fiftieth Street, or subway to Fiftieth Street, are the nearest rapid transit connections.)

The headquarters for registering and information will be opened on Thursday evening at the hotel quarters, Hotel Cumberland, Fifty-fourth Street and Broadway. On Friday morning and afternoon the office for registering and information will be at the College of the City of New York, Chemistry Building (enter from plaza, and register in Wolcott Gibbs library at right entrance to the building). Telegraph and telephone arrangements will be provided. Calls for members may be sent to 1280 Audubon, Department of Chemistry or to Prof. Baskerville's office. On Saturday, Oct. 31, the offices are at the Chemists' Club, the telephone connection being 281 Columbus.

Badges will be given at the time of registration to all members, and to applicants who have deposited their initiation fee. Special badges will be provided for guests, including ladies, who must be introduced by a member and sign the registration book.

As already stated, the hotel headquarters are at the Hotel Cumberland, Fifty-fourth Street and Broadway, two blocks west and one block south of the Chemists' Club.

On Thursday evening, Oct. 29, a meeting of the board of directors will be held in the Chemists' Club, in the library, second floor.

The convention proper begins on Friday, Oct. 30, in the Doremus Lecture Theater, College City of New York, at 9 a. m. Prof. Baskerville, director of the laboratory, will introduce President J. H. Finley, who will welcome the society.

The following papers will then be read and discussed:

(1) The use of a mercury cathode in the determination of metals. A. Harold Porter and Francis C. Frary.

(2) The passivity of nickel and iron. E. P. Schoch.

(3) Equilibria in standard cells. G. A. Hulett.

(4) Chemical energy. J. E. Mills.

(5) The formation of nitric acid from air by means of low-voltage direct current. G. W. Morden.

At 12:30 p. m. luncheon will be taken by invitation of the staff of the Department of Chemistry of the College of the City of New York, in Alumni Hall, main building. Ladies are invited.

A 20-minute organ recital, complimentary to the society, will be given at 1:40 p. m. by Prof. Samuel A. Baldwin, head of the department of music, in the Great Hall, second floor, main building.

At 2 p. m. the second session, devoted to the reading and discussion of papers, will be held in the Doremus Lecture Theater.

(6) Electrolytic corrosion of the bottom of oil tanks. A. A. Knudson.

(7) The corrosion of underground structures. Albert F. Ganz.

(8) The function of oxygen in the corrosion of metals. W. H. Walker.

(9) The theory of electrolytic paints. W. D. Bancroft.

(10) Simple methods for the prevention of electrolytic corrosion. Maximilian Toch.

In the evening, at 7:30 p. m., an informal subscription dinner will be held at Reisenweber's, Columbus Circle, Fifty-eight

Street and Eighth Avenue, New York City. Ladies are especially invited to attend.

The third professional session will be held on Saturday, Oct. 31, at the Chemists' Club, 108 West Fifty-fifth Street, when the following papers will be read and discussed:

(11) The Lash steel process and the electric furnace. F. A. J. Fitzgerald.

(12) Utilization of power stations for electrochemical and electrothermal processes during periods of low load. E. A. Sperry.

(13) Electrochemical loads and the central station. John Meyer.

(14) Correct methods of measuring stray currents. Clayton H. Sharp.

(15) The latent heat of vaporization of zinc. W. McA. Johnson.

(16) Heat losses of furnaces through walls. Carl Hering.

Luncheon will be taken at 1 p. m. at Hotel Cumberland, Fifty-fourth Street and Broadway. Ladies are invited.

At shortly before 2 p. m. the party will leave Hotel Cumberland for an excursion to the Balbach Smelting & Refining Works, in Newark, N. J., where the processes of smelting and refining of copper, lead, silver and gold may be seen. An illustrated description of this plant, which is the pioneer copper refinery in the United States, may be found in our Vol. II, page 303.

In the evening a "smoker" will be tendered to the American Electrochemical Society by special invitation of the Chemists' Club, in the assembly room of the club, 108 West Fifty-fifth Street.

The Iron and Steel Market.

October has been a very quiet month marketwise, doubtless on account of the pendency of the national election. Production has been fairly well maintained and has lost little, if any, from the September rate. There has not been the spurt in tonnage output which usually occurs in October on account of weather conditions being particularly favorable for furnace and mill operations.

It is improbable that there will be much further gain in production during the remainder of the year. Pig iron production gained rapidly and steadily in July, August and September. Official statistics are available for production during the first half of the year, while unofficial monthly statistics have been gathered of coke and anthracite pig iron production. If the production in the second half should be the same as in the first half the year's total would be 13,836,000 tons. If the fourth quarter output should be the same as in the third quarter the total would be 15,042,000 tons. If the rate of September should be maintained through the fourth quarter the year's total would be 15,400,000 tons. The safest estimate would probably be 15,500,000 tons, with a probable error of less than a quarter million tons in either direction.

Production of rails, sheets and tin plates fell off in October as compared with September. On account of the season rails promise a further decrease, while sheet and tin plate production is likely to increase. Production of plates and merchant bars may increase, but it is not probable that shapes, wire products and tubular goods will be able to do more than hold their own.

ORE AND BLAST FURNACE DEVELOPMENTS.

During the month the interesting announcement was made that M. A. Hanna & Co., the large Lake Superior ore producers, would build two merchant blast furnaces at Buffalo, to be ready for operation early in 1910. The firm has a 10-year lease on three smaller furnaces at Buffalo, which lease expires two years hence and will not be renewed. A decision at this time to build new merchant furnaces, when almost half the merchant furnace capacity of the country is idle, may seem somewhat startling, but it is exactly in line with current developments. The merchant furnace production of the Central West

was formerly almost wholly in the hands of interests which bought their ore year by year from the merchant Lake Superior ore producers, at the season price. In recent years Lake Superior ore properties have come to be tightly held and, especially since the Hill lease to the steel corporation, it is difficult to acquire favorable leaseholds.

A number of merchant blast furnaces have been built by ore interests. For months after the October panic the merchant furnaces endeavored to peg the pig iron market, but without avail, while the ore producers have practically maintained their market, making a reduction of only 50 cents a ton for this season.

The pig iron market has gotten down to the bare cost of production to a furnace which must buy its ore at the season price. There is an excellent profit in the ore, and practically none in the pig iron. While there is evidently a surplus in furnace capacity as a whole, the capacity of merchant furnaces controlled by ore interests is far below the possible minimum demand.

The prospects are quite clear that Lake Superior ore prices will be maintained fairly well, but to be certain of disposing of ore the producers must convert it into pig iron themselves. That is the meaning of M. A. Hanna & Co.'s decision to build two blast furnaces. Corrigan, McKinney & Co., another large merchant ore interest, have plans to build a twin furnace to their present Josephine, which will give them four furnaces, two Josephine, Scottdale and Genesee.

PIG IRON.

The Pittsburg Steel Company has covered a portion of its pig iron requirements for the next five years. It has recently completed a basic open-hearth steel plant of eight 60-ton furnaces, as an adjunct to its wire plant at Monessen, Pa., making the first steel at the beginning of August last. Occasional purchases of prompt pig iron have been made, the last being made the latter part of October, 10,000 tons from the Struthers Furnace Company at \$14, furnace, delivery 500 tons daily. About the same time a contract was concluded with the Penn Iron & Coal Company, an interest of M. A. Hanna & Co. operating a furnace at Canal Dover, Ohio, for 6000 tons of basic pig iron a month for five years commencing Nov. 1. The price is 7 per cent advance over the actual cost of production, but in no case is to exceed \$17. What the actual price will be cannot be stated, as certain terms going to make up the actual cost of production are not disclosed, in particular the cost of the ore, as the furnace company would not necessarily pay the season-to-season price to M. A. Hanna & Company. The Allegheny Steel Company bought 5000 tons of basic pig iron, delivery over the balance of the year, at about \$14, furnace.

Sales of Bessemer have been very light. The Bessemer average for September was \$15, valley, but the market is weak at that price for early delivery. Foundry iron has sold at \$15.25, delivered Pittsburg, and forge at \$14.50. We quote the valley market for early delivery at \$14 for basic, \$14.25 to \$14.50 for malleable, \$15 for Bessemer, and \$14.35 to \$14.50 for No. 2 foundry. For delivery next year these prices could not be done, producers asking 25 to 50 cents advance.

BILLETS AND SHEET BARS.

The market has been very quiet, enlivened only by some purchases of forging billets in the Chicago district and the making of a contract between the Inland Steel Company, Chicago, and the Railway Steel Spring Company, for about 25,000 tons of rolling and forging billets, deliveries running well into next year. The market remains at \$25, Pittsburg, for billets, and \$27, Pittsburg, for sheet bars, half the freight being conceded when it is from \$1 to \$3 a ton.

FINISHED MATERIALS.

There is some shading in plates, sheets, tin plates and possibly also in structural shapes. In some of these lines there has been very quiet shading for two or three months, while concessions are now given more openly. While they do not cover all transactions in any of the commodities they are rather wide-

spread. In the case of structural material concessions are believed to be given only to fabricating interests in the case of some large structural contracts and to amount to about \$2 a ton. Plates are shaded quite generally as to some sizes by \$1 to \$2 a ton. Light rails are being shaded \$1 to \$2 from the official price of \$25, but this has been the rule for months. Black sheets are sometimes shaded a dollar a ton, and galvanized sheets \$2 a ton, while tin plates are shaded sometimes by 5 cents a box or more.

It appears that the large interests have been averse to taking open cognizance of these irregularities by official reductions in the recognized prices, perhaps wishing to avoid attracting public attention just before the election, or perhaps in the hope that the market would firm up after that event. At any rate, if the irregularities do not disappear after the election it is probable that some formal reductions will be made before the turn of the year.

Official prices, which, as noted, are not always observed in the case of some products, remain as follows, Pittsburg:

Standard rails, \$28.

Light rails, \$25.

Plates, 1.60 cent for tank quality.

Shapes, 1.60 cent for beams and channels, 15-in. and under, angles and tees.

Steel bars, 1.40 cent; iron bars, 1.35 cent to 1.40 cent; Chicago, 1.50 cent.

Plain wire, 1.80 cent; wire nails, \$1.95.

Sheets, 2.45 cents, net, for black; 3.50 cents, net, for galvanized, 28 gage.

Tin plates, \$3.65, net, for 100-lb. cokes.

The Aluminium Industry in Europe.

As mentioned in a recent issue of the London *Electrical Review*, the conditions in the aluminium industry have become less satisfactory to European producers in the past year or two in consequence of the increase in competition and the fall in prices, although the latter circumstance has naturally been of advantage to consumers.

The *Neue Züricher Zeitung* now announces that the existing community of interests (the international convention) will be abolished at an early date with the object of offering keener rivalry to the new competitors. It may be remembered that a firm association of all the then existing aluminium producers was formed in November, 1901, but as the objects of the convention have now been crossed by outsiders, it is proposed to abolish the agreement. While going to press, we hear that this had been formally done on October 1. The price difference in London between copper and aluminium is now slight; the London price of electrolytic copper on October 9 was £64 to £65, aluminium £70 to £75 per ton.

CORRESPONDENCE.

Electrolytic Production of Metal Sheets.

To the Editor of *Electrochemical and Metallurgical Industry*:

SIR:—My attention has been drawn to Mr. T. A. Edison's Patents Nos. 880,484 and 879,859, dated Feb. 25, 1908, for "Improvements in the Manufacture of Very Thin Sheet Metal." Since the method is very similar to my Patent No. 20,073 of 1895, I think an abstract from my Patent No. 20,073 of 1895 will be of interest.

"The object of my invention is to provide means for obtaining metal in the form of sheets or strips or other forms, by electro-deposition where it is required that the metal sheet or other form of metal to be obtained, shall be entirely made by electro-deposition, as distinguished from an article consisting of a permanent basis, or backing, covered with an adherent coating of metal effected by electro-deposition.

"It is necessary in producing sheets or other metal forms,

consisting entirely of electro-deposited metals, to provide a cathode, or base, upon which the metal is deposited but from which the deposited metal can be afterwards readily removed.

"It has hitherto been necessary to provide a cathode for this purpose which is covered by a greasy or fatty matter, such, for example, as wax dissolved in benzene, but it has been found in practice that it is impossible to ensure such a coating as shall be so perfect as to prevent the adherence of the deposited metal to the cathode in places, which, however minute, will prevent the subsequent removal from the cathode of the deposited metal in a perfect form.

"I have, by trial and experiment, found that a large percentage of aluminium, or an alloy, or compound containing a large percentage of aluminium, will receive an electro-deposition of metal, and that the metal so deposited can afterwards be readily separated from the said cathode: for example, I may remove it by rubbing it therefrom or by stripping it in the form of sheets. I prefer the former plan for the removal of deposited gold. The non-adherence of the deposited metal is owing, I believe, to the formation of a thin and even loose coating of oxide on the described cathode, which whilst not interfering with the electro-deposition of the metal thereon, prevents such adherence of the deposited metal to the cathode as will interfere with the removal, in perfect form, of the deposited metal from the cathode. If an aluminium alloy be used I find that, to give good results, the amount of aluminium should not be less than about 50 per cent of the alloy. The invention can be applied to the deposition of various metals such, for example, as gold, zinc and iron. The cathodes may be made of any suitable form such as plates, or continuous bands traversed through the electrolyte or of drums revolving therein."

LONDON, ENGLAND.

SHERARD COWPER-COLES.

Cost of Water Power in Norway.

To the Editor of *Electrochemical and Metallurgical Industry*:

SIR:—I have read with great interest the letter of Mr. F. A. J. FitzGerald on page 353 of your September issue. From what he says on the cost of electric power in electrometallurgy of iron and steel, I note that he prefers to base estimates of cost on a rate of \$15 per hp-year at the electric furnace terminals under American conditions.

If we had to figure with such a price in Norway the prospects for the future industrial development of the electrometallurgy of

Bergen and Mendal, is between 6.6 and 7.3° C. It will further be seen that not in any month of the year the mean temperature drops below the freezing point of water. This corresponds nearly to the climate of Milan, Italy. In the valley of Hardanger, which is rightly called the orchard of Norway, even tobacco culture is successfully carried out.

1903.	Ullensvang.	Bergen.	Mendal.
January	3.7° C	1.3° C.	0.2° C.
February	2.1	2.9	3.5
March	3.8	4.7	4.3
April	4.5	5.1	4.6
May	2.7	2.5	10.2
June	13.0	12.3	14.7
July	14.1	13.7	14.4
August	12.4	12.1	13.7
September	11.2	11.7	11.5
October	5.6	7.1	6.6
November	2.5	3.8	3.3
December	1.3	2.8	0.8

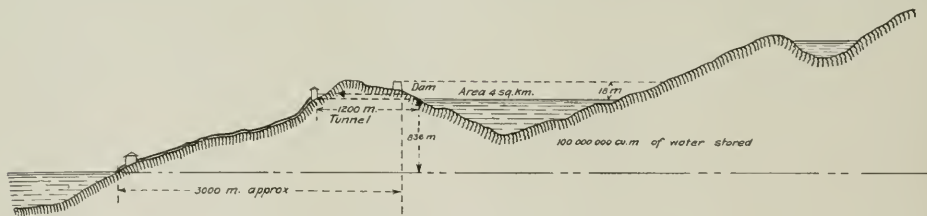
Mean..... 6.6° C. 7.3° C. 7.3° C.

Most characteristic, however, for these regions is the enormous quantity of rain and snow which falls on these high plateaus. The storms coming from the ocean bring along clouds, which, when they approach the coast, are forced to rise somewhat like 1000 meters or more. Rain results, and the water collects in the great natural reservoirs on top of the plateaus.

I would like to give some further data concerning one fall, which, in the course of the last few years, has been fully investigated and which is particularly characteristic for most of the falls in the north and west of Norway.

This waterfall is situated on the Hardanger Fjord, near a port always free from ice and open for the whole year for the largest ocean vessels. The water power available during the entire year, day and night, would be more than 26,000 hp if a single dam of 18 m height for storage of the water would be erected.

The adjoining sketch shows that the height of the fall is 863 m (the figure 836 in the diagram being a mistake and 863 should be substituted). The distance of the dam from the ocean is about 3 km. The water would have to be carried through a tunnel of 1200-m length and then run down through steel tubes to the power station. A further dam erected in con-



SKETCH OF NORWEGIAN WATER POWER.

iron and steel in Norway would be less favorable than they appear to us now. It may be of interest to your readers to state some facts concerning the water powers available in Norway, and especially those in the west and the north of Norway.

The hydrographic chart of Norway shows that the western coast, which is sharply cut up by fiords, rises rapidly from the sea to high plateaus with large reservoirs and immense glaciers, like the Følgelund, which is the largest glacier in Europe.

Moreover, the climate is remarkable, the mean temperature being rather high. This is due to the gulf stream. According to the following table, the mean temperature during different months of the year at three places at the coast, Ullensvang,

nection with the little lake higher up would permit the utilization of some 30,000 hp.

According to the tenders received from leading European and American firms, the electric horse-power developed would cost about 105 francs (\$33), to which would have to be added the price for the waterfall, about 30 francs (\$6) per horsepower; and of the ground, which should be, without doubt, not more than 1 franc (20 cents) per square meter. The total cost to the owner should not be more than 30 or 35 francs (\$6 or \$7) per hp-year, and this is right at a harbor free from ice in an excellent populated district.

KRISTIANIA, NORWAY.

ALBERT HIORTH.

The Bunsen Monument in Heidelberg.

On August 1 many prominent chemists and chemical engineers from all parts of Germany assembled in Alt Heidelberg to attend the unveiling of the statue of Robert Bunsen. The monument, which stands in the park opposite the Märzgasse, is the work of Professor Volz, in Karlsruhe. The necessary funds had been subscribed for by individual chemists and by the large German chemical corporations.

The bronze statue of Bunsen forms the center of the monument. On the two sides of the flight of stairs which lead up to the statue are two figures, one representing science hidden, the other science free. These figures as well as the stairs are made of Black Forest granite.*

Geheimrat Prof. Th. Curtius was the first speaker. He presented in the name of the committee the monument to the city and gave a brief sketch of Bunsen's work in Heidelberg. Bunsen



BUNSEN MONUMENT IN HEIDELBERG.

sen came to Heidelberg in 1852. For 13 years he had already carried out important research work in Marburg and Breslau with respect to cacodyl compounds, the blast-furnace process, the composition of the earth crust, etc.; he had already invented the "Bunsen cell" and had succeeded in producing magnesium by electrolysis.

On Aug. 6, 1852, Bunsen became professor of chemistry at the University of Heidelberg and director of the chemical laboratory in the Dominican Monastery. At the same time funds were promised him for a new laboratory. This was erected in the years 1853 to 1855.

Bunsen felt at once at home in Heidelberg and was on excellent terms with the political powers in Karlsruhe, as appears from a letter written by him on Oct. 29, 1852, to a friend: "Es lebt sich himmlisch hier in Heidelberg. Ich sehe schon jetzt, dass ich diesen Schritt nie bereuen werde In Karlsruhe weiss man nicht, was man mir alles zuliebe tun soll. . . . Mir wird oft angst und bange, wie ich so grossen Erwartungen entsprechen soll."

In continuation of his work on magnesium he now carried out the production of aluminium, sodium, barium, calcium and lithium by electrolysis of the fused chlorides. For the determination of the specific heat of the new metals and their atomic

*In the *Zeitschrift für Electrochemie*, Sept. 25, from which the accompanying illustrations are reproduced, E. Cohen refers to the words of Sir Humphry Davy with respect to the use of granite: "In all cases when great public monuments are to be erected this is the stone that should be employed."

weights he devised the ice calorimeter. Together with Roscoe he carried out from 1852 to 1862 photochemical investigations which have become classical. Together with Kirchhoff he visited in 1862 Roscoe in England. The photograph reproduced below was taken at that time in Manchester.

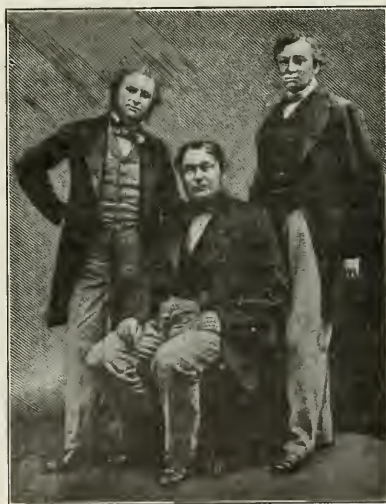
In 1860 the first joint paper by Bunsen and Kirchhoff on spectral analysis appeared. In this investigation the "Bunsen



ROBERT BUNSEN.

burner," which he had devised in 1855, did excellent service. The spectral-analytical work led to the prophecy of new elements and this was fulfilled when Bunsen himself isolated rubidium and caesium during the next year. He then developed many analytical methods and wrote *Gasometrische Methoden* (1857) and *Flammenreaktionen* (1880).

In the laboratory Bunsen trained his students chiefly in the different branches of analytical chemistry and never got tired



R. BUNSEN, G. KIRCHHOFF, H. ROSCOE (1862).

to teach the beginners all the little methods and tricks which he had himself invented. At the age of 78 years he retired as professor in 1880 and enjoyed the rest of his life quietly in Heidelberg. He died on Aug. 16, 1890.

After the conclusion of Professor Curtius' speech, which was the chief address of the day, Dr. Wilkens, as mayor of the city of Heidelberg, accepted the monument for the city. He spoke of Bunsen as man, of his kindness and modesty, and of the love and admiration which all Heidelberg citizens entertained for him.

Geheimrat Britschli, representing the mathematical-physical faculty of Heidelberg University, announced that the faculty

had conferred the honorary degree of doctor of philosophy to Adolf von Baeyer in Munich and Jakobus Henricus von't Hoff in Berlin.

The German Bunsen Society (which erected to Bunsen another monument, *aere perennius*, a few years ago, by gathering his complete papers in three handsome volumes) was represented by its president, Dr. Paul Marquart. Among the many other speakers were Landolt for the Deutsche Chemische Gesellschaft, Car for the Verein Deutscher Chemiker, Holtz for the Verein zur Wahrung der Interessen der Chemischen Industrie Deutschlands and Bernthsen for the chemical industry.

In the name of the Grand Duke of Baden, Minister von Dusch placed a laurel wreath at the foot of the monument, while another wreath was laid down in the name of Bunsen's friend of many years, Sir Henry Roscoe.

The Complete Analysis of Brass.

By ALBERT J. HALL.

The present up-to-date foundryman is surely, though perhaps slowly, bringing the operations of the foundry to a scientific basis. The chemist is his co-partner in the work. An accurate knowledge of the composition of his metals is very essential, and must be had to practice economy and to remedy evils existing in the metals due to an excess of certain constituents, or to the presence of impurities in amounts detrimental to the alloy.

In present practice, the routine analysis of the cast work is for copper, tin, lead, and zinc. This is necessary to regulate and keep uniform the various formulae used. In the case, however, of the analysis of dust or borings returned from the brass shop, foreign scrap, and composition ingot metal, all of which are used in the cheaper castings, iron and antimony determinations become necessary. These determinations regulate the amount of remelted metals used in each furnace heat so as to keep the iron and antimony content in the castings below the detrimental limit.

In red brass of average composition, the tin content usually runs from 1.5 to 10 per cent; the lead from 2 to 12 per cent; the copper from 75 to 90 per cent; and the zinc from 1.5 to 15 per cent. The iron is usually below 0.30 per cent, the antimony below 0.5 per cent, and the arsenic below 0.5 per cent.

In yellow brass the zinc runs up to 40 per cent and the copper lies between 60 and 75 per cent.

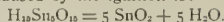
Tin Determination.

Weigh out very accurately 2.5 grams of brass. Transfer it to a 250-c.c. beaker; add enough water to cover it and then add 10 c.c. of nitric acid, sp. gr. 1.42. Immediately cover it with a watch glass and add more water if the action becomes too violent. Heat until all the metal is dissolved or until the metal is completely decomposed. Add about 40 to 50 c.c. of hot water and boil for about five minutes. At this dilution, the tin will completely precipitate. Let the precipitate of metastannic acid settle, then filter through a number 580 white ribbon S. and S. brand filter paper or one equally as good.

If a filter paper suitable for holding a lead precipitate is used, too much time is consumed in filtering. In any case, the filtering will be accelerated by having a clean funnel and having a filter paper fit the funnel exactly, for then, the funnel stem will completely fill with liquid and a natural suction will be produced; thereby increasing materially the rate of filtering. Too much stress cannot be put on these seemingly unimportant details in all cases wherever rapid filtering is desired.

Wash thoroughly with a hot 2 per cent solution of nitric acid. Dry the filter paper with the precipitate in an oven, ignite in a clean weighed porcelain crucible, observing the usual precautions of slow charring and burning of the filter paper. When the filter paper has burned off, put the crucible in full heat of the burner for ten minutes or in a blast lamp for five minutes. Cool the crucible partly in the air, then finally in a desiccator. Weigh as tin oxide SnO_2 .

The reaction caused by the ignition is:



From the weight of tin oxide found, calculate the per cent of tin present.

If there is any antimony in the alloy, it will be precipitated with the tin and weigh up as Sb_2O_3 . After the antimony determinations, calculate the weight of Sb_2O_3 present here and deduct it from the combined weights of SnO_2 and Sb_2O_3 . Then calculate the per cent of tin. (See Antimony Determination.)

Lead Determination.

The filtrate from the tin contains the nitrates of copper, lead, and zinc. Add 10 c.c. of sulphuric acid, sp. gr. 1.84, and evaporate on a water bath or hot plate until all the nitric acid is driven off and the metals are in the sulphate condition. The change of color from dark blue to light blue or gray is an indication of the absence of nitric acid. It is a great saving of time to arrange the work so that the filtrate can be evaporating on the steam bath over night. In the morning, all the nitric acid will be gone and the analysis ready to be continued. The steam bath is by far the more satisfactory for it can be run over night and, moreover, there is no danger of spattering as is the case when on a hot plate.

When all the nitric acid is removed, cool a few minutes, then add about 200 c.c. of hot water, and dissolve the sulphates of copper and zinc. The lead will be left as a white precipitate. Heat the solution to the boiling point, then let it cool and the precipitate of lead sulphate settle. Filter through a fine, firm filter paper, and wash very thoroughly with a 5 per cent solution of sulphuric acid. Remove the filtrate, and finish the washing with a solution of alcohol and water in proportion 1:1. The purpose of the washing with alcohol, which ought to be very thorough, is to remove the sulphuric acid as its presence in even very small amounts causes a disintegration of the filter paper during the drying, and renders subsequent removal of the precipitate impossible.

When all the sulphuric acid is removed, as shown by testing the washings with hydrochloric acid and barium chloride, dry the filter paper in an oven. Open the filter paper and carefully remove the precipitate by means of a clean spatula and camel's hair brush to a piece of glazed paper. Cover the paper with a watch glass to prevent the escape of some of the precipitate which might otherwise be blown away by draughts. Fold the paper and burn it on a platinum wire over a weighed porcelain crucible. Jar the ashes, and any unburned paper, due to poor washing with alcohol, off the wire and put the crucible over the lowest possible flame and finish the burning. A low temperature is very essential.

Even with the best precautions, some lead sulphate that stuck to the filter paper will be reduced to metallic lead by the action of carbon and on heating it will be oxidized to lead oxide PbO . If the temperature is high the lead volatilizes. When the filter paper is burned, allow the crucible to cool slightly. Add three drops of nitric sulphuric acid made up in the proportion of three parts nitric acid and one part sulphuric. Now put the crucible on the edge of a hot plate and leave until all the nitric acid has evaporated. This will take only a few minutes. Then move to the center of the hot plate, and drive off all the sulphuric acid. Be sure that no acid is left condensed on the sides of the crucible. The lead and lead oxide are thus all converted to lead sulphate. Remove the crucible from the hot plate and allow it to cool. Then add the main bulk of the precipitate, and put the crucible over a very small flame for four or five minutes. Do not let the bottom of the crucible get above a light cherry-red color. Cool as before, first in the air, and then in a desiccator. Weigh as lead sulphate. From this weight, calculate the per cent of lead present.

Copper Determination—By Electrolysis, Using Rotating Anodes.

Dilute the filtrate from the lead precipitate to exactly 500 c.c. in an accurately graduated volumetric flask. Shake the solution

thoroughly in order to make it uniform throughout. Take one-tenth of this filtrate, viz., 50 c.c., and use it for both the copper and zinc determinations. Dilute this 50 c.c. to about 125 c.c., preferably in a tall non-lipped 150-c.c. beaker. Add 2 c.c. of acid (3 parts nitric and 1 part sulphuric), and $\frac{1}{2}$ gram ammonium nitrate. Heat the solution to almost boiling and plate out the copper on platinum gauze cathodes using a current N. D. 100 equal to 4-5 amp for each cell. The pressure should be at least 3 to 4 volts for each cell. Rotate the anode about 600 to 800 times per minute. Cover the beaker with split watch glasses to prevent a loss of liquid due to the rapid evolution of gas from the anodes. The copper will be precipitated in from 20 to 25 minutes.

When the precipitation of the metal is complete, which may be ascertained by removing a drop or two with a capillary tube or dropper, and bringing it in contact with a drop or two of hydrogen sulphide water; a brown coloration indicating copper; reduce the current to about 2 amp, never below,* and remove the cathodes. Wash them well when removing them, taking care that neither cathode remains in the liquid an instant after the current is broken. This is done by short-circuiting the one being removed when the connection is broken and letting the current pass through the second one until ready to be removed. Wash the cathodes in alcohol, and then dry them in an oven at 100 deg. Cent., care being taken to see that they do not remain in the oven longer than is necessary to dry them. Otherwise, oxidation may take place and the determination will be spoiled. A quicker way of drying the cathodes is to cautiously hold them over an open flame, an Argand burner preferred, until just dry. Cool in a desiccator, and weigh as metallic copper. The weight multiplied by 10 gives the weight of copper in the whole sample. From the weight obtained, calculate the percentage of copper present.

The deposit, if a good one, will be smooth, adherent, hard, and a salmon pink color. Duplicates should check within 0.3 or 0.4 of a milligram or the determination should be rejected.

A plating very red in color is an indication of too much acid. A spongy deposit at the bottom is a manifestation of too much current for the concentration of the copper ions in the liquid.

For stationary anodes, the current should be very materially reduced (to about 0.5 amp) and the time taken for the plating would be about 12 to 15 hours.

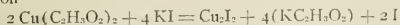
Copper Determination—Volumetric Method.

The method used is that of Low.**

STANDARDIZATION OF THE THIOSULPHATE SOLUTION.

Prepare a solution of sodium thiosulphate containing about 19 grams of the pure crystals to the liter. Standardize as follows: Weigh accurately about 0.200 gram of pure copper foil, and place in a flask of about 250 c.c. capacity. Dissolve by warming with 5 c.c. of a mixture of equal volumes of strong nitric acid (sp. gr. 1.42) and water and then dilute to about 50 c.c. Boil for a few moments to partially expel the red fumes and then add 5 c.c. of strong bromine water and boil until the bromine is thoroughly expelled. The bromine is to ensure the complete destruction or removal of the red fumes.

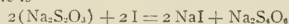
Remove from the heat and add a slight excess of strong ammonia water. Ordinarily it suffices to add 7 c.c. of ammonia water of 0.90 sp. gr. Again boil until the excess of ammonia is expelled as shown by a change of color of the liquid and a partial precipitation of the copper hydroxide or oxide. Now add strong acetic acid in slight excess, perhaps 3 or 4 c.c. of the 80 per cent acid in all, and boil again for a moment if necessary to redissolve the copper. Cool to room temperature and add about 3 grams of potassium iodide or 6 c.c. of a solution of the salt containing 50 grams in 100 c.c. Cuprous iodide will be precipitated and iodine liberated according to the reaction



*If the current is reduced too much, the counter current generated may dissolve off some of the deposit.

***Jour. Amer. Chem. Soc.*, Vol. 24, p. 1082.

The free iodine colors the mixture brown. Titrate at once with the thiosulphate solution until the brown tinge has become weak and then add sufficient starch liquor to produce a marked blue coloration. Continue the titration cautiously until the color due to free iodine has entirely vanished. The blue color changes toward the end to a faint lilac. If at this point the thiosulphate be added drop by drop and a little time be allowed for complete reaction after each addition, there is no difficulty in hitting the end point within a single drop. One c.c. of the thiosulphate solution will be found to correspond to about 0.0005 gram of copper. The reaction between the thiosulphate and the iodine is



Sodium iodide and tetrathionate are formed. The starch liquor may be made by boiling about 0.5 gram of starch with a little water and diluting with hot water to about 250 c.c. The liquor should be homogeneous and free from lumps or grains. It should be used cold and must be prepared frequently, as it does not keep well. The thiosulphate solution made from the pure crystals and distilled water appears to be quite stable, showing little or no variation in a month under reasonable conditions.

For the determination use 50 c.c. of the filtrate from the lead determination. Put it in a flask, add ammonia, boil off excess, add acetic acid, and titrate exactly as described for the standardization. From the amount of the thiosulphate solution used calculate the percentage of copper present.

Zinc Determination—By Electrolysis, Using Rotating Anodes.

Evaporate the filtrate from the copper determination by electrolysis, which must be free from copper, on a steam bath until the volume of the solution is 3 to 4 c.c. To insure the complete removal of the nitric acid, which is very essential, heat the beaker containing the filtrate over a flame keeping the beaker in constant motion to prevent spattering until dense white fumes from the sulphuric acid are given off freely. This operation takes about two to three minutes. Cool the beaker in the air, then add 120 c.c. of water and 6 grams of solid sodium hydroxide. (Too much sodium hydroxide produces a poor black deposit which is always too heavy.) Warm and stir the solution until all the sodium hydroxide is dissolved. Heat to about 60 deg. Cent. and plate out the zinc, using a current N. D. 100 equal to 4 amp for each cell. The pressure is generally about 5 to 6 volts for each cell.

For each zinc determination use the copper plated cathodes from the copper determination, as zinc plated on platinum produces platinum black which is very hard to remove and which materially diminishes the weight of the cathodes. A silver plated cathode may be used instead of a copper plated one, if it is desired. Have all the connections made and some current on so that the plating starts immediately after the cathode touches the liquid. The anode should make about 600 revolutions per minute. The zinc will be plated out in 25 minutes.

When the metal is completely precipitated, which may be ascertained by removing a small quantity of liquid, acidifying it with sulphuric acid, and bringing it in contact with a drop or two of a solution of potassium ferrocyanide (the presence of zinc producing a cloudiness in a very short time), reduce the current to 2 amp, as in the copper determination, and remove the cathodes, using the same precaution as required for the copper determination. Wash the cathodes in alcohol and dry as before in an oven or over a naked flame. Cool in a desiccator, and weigh as metallic zinc. The weight multiplied by 10 gives the weight of zinc in the whole sample. From the weights obtained, calculate the percentage of zinc present. Duplicates should check within very close limits.

The deposit, if a good one, will be hard, adherent, and light gray in color.

The copper plated cathodes can be used for several zinc determinations by dissolving the zinc off the cathodes in rather dilute nitric acid. If the cathodes are allowed to remain in the

acid solution only a moment, the copper layer will be but slightly attacked, and after washing in alcohol and drying, they will be ready for another deposition of zinc.

The method as given above applies only to rotating anodes. With the stationary anodes, I would add 2 to 4 grams solid sodium hydroxide, dilute to 125 c.c., heat to 50 deg. Cent., and electrolyze with a current of N. D. 100 equal to 0.7 to 1.5 amp. All the metal ought to be deposited in about two hours.

Another method that has found favor with some chemists is to mix the solution of zinc sulphate, neutral as possible, with an excess of neutral potassium oxalate until the precipitate, which at first appears, redissolves. Heat the solution to 50 or 60 deg. Cent. and electrolyze with N. D. 100 equal to 0.5 to 1.5 amp. About two hours will be sufficient for complete precipitation.

If there is any iron present, it will be precipitated with the zinc. Dissolve off the zinc in dilute hydrochloric acid and precipitate the iron by ammonium hydroxide. Filter off the precipitate, dissolve it in hydrochloric acid, reduce it with stannous chloride solution and titrate the iron with a standard solution of potassium permanganate. From the amount of the solution used determine the amount of iron present. Subtract the iron found from the weight of zinc.

Zinc Determination—Gravimetric Method.

The method used depends on the precipitation of zinc as zinc ammonium phosphate and its subsequent ignition to zinc pyrophosphate. It is carried out as follows: Take 250 c.c. of the filtrate from the lead determination, containing copper and zinc as sulphates. To remove the copper, add 35 c.c. of sulphurous acid, heat to boiling and add 5 or 6 grams of ammonium sulphocyanate. If the precipitate of copper sulphocyanate is not white or cream color, add more sulphurous acid. Allow the precipitate to settle, then filter off and wash with hot water. Use a fine filter as the precipitate sometimes has a tendency to run through. To the filtrate from the copper sulphocyanate, add 35 c.c. of ammonia water (sp. gr. 0.90) or enough to make strongly alkaline, and 50 c.c. of a 10 per cent solution of ammonium phosphate. The presence of an excess of ammonium phosphate decreases the solubility of the zinc ammonium phosphate.

Make up to approximately 500 c.c., heat to boiling and cautiously neutralize with nitric acid (sp. gr. 1.20) added from a dropper until a slight permanent turbidity is produced. Then discontinue the addition of nitric acid and add acetic acid (1:25) 1 c.c. at a time from a dropper. Continue the addition until only a faint odor of ammonia is perceptible. Heat the solution up again to boiling and stir until the precipitate is granular. If the precipitate does not become granular after considerable stirring, it is best to dissolve it in ammonia and reprecipitate as directed above.

Filter off the precipitate of zinc ammonium phosphate, wash with cold water, ignite carefully in a platinum crucible and weigh as zinc pyrophosphate $\text{Zn}_2\text{P}_2\text{O}_7$. From this weight, calculate the percentage of zinc present.

The copper may be removed, before precipitating the zinc, by sulphuric acid, but the separation by ammonium sulphocyanate and sulphurous acid is much the neater of the two.

Iron Determination.

Weigh out 5 grams of the sample turnings, previously freed from iron filings, etc., by a magnet, into a 250-c.c. beaker or a 250-c.c. casserole, preferably the latter. Add about 40 c.c. of water and then 20 c.c. of nitric acid, sp. gr. 1.42. Heat until the metal is completely disintegrated. Then add 15 c.c. of sulphuric acid, sp. gr. 1.84, mixed with an equal quantity of water. Put over the steam bath and evaporate off all the nitric acid. Dilute to about 200 c.c. and boil for a minute or two. Let it settle and cool. Filter out the tin and lead precipitate and wash with a 5 per cent solution of sulphuric acid. The iron is in solution in the filtrate. Dilute the filtrate to about 750 to 800 c.c. in a liter beaker. Heat the solution to boiling

and add concentrated ammonium hydroxide until the solution turns a very dark blue color. It is an indication that the copper and zinc which were precipitated at first are redissolved. The iron will be precipitated as ferric hydroxide. It is necessary to have the bulk of the solution about 800 c.c. before precipitating the iron in order to keep the zinc in solution.

Boil the solution about five minutes, let it settle and then filter through a thin, rapid filtering, filter paper. Wash the precipitate with hot water containing a little ammonia. Put a 250-c.c. Erlenmeyer flask under the funnel and dissolve the ferric hydroxide off the filter by means of hot concentrated hydrochloric acid. Wash the filter paper very thoroughly with hot water, and then put on more acid and follow it with more hot water. Two or three such applications are sufficient to dissolve off all the precipitate. Put the flask over a burner and heat to boiling. Then add sufficient stannous chloride solution to completely decolorize it. Remove the flask from the fire and according to Blair's method for iron add 60 c.c. of mercuric chloride solution. Put under running water and cool as soon as possible.

In a large porcelain evaporating dish, put 600 c.c. of water and 60 c.c. of phosphoric acid solution. When the iron and mercuric chloride solution is cool, add it to the solution in the evaporating dish. Rinse out the flask into the dish and titrate the iron at once with a standard solution of potassium permanganate. Add the latter until a permanent tinge of pink is produced. If beyond the end point, titrate back with an equivalent standard solution of ferrous sulphate. Subtract the number of cubic centimeters of ferrous sulphate solution used from the number of cubic centimeters of permanganate solution required. From the data obtained, calculate the percentage of iron present.

Standardization of Potassium Permanganate.

Weigh out 100 to 150 mgs. of small pieces of iron wire of known purity. Have the pieces clean and bright. Put in an Erlenmeyer flask, pour on 60 to 70 c.c. of water and add 2 grams of sodium bi-carbonate. Shake until the carbonate is all dissolved. Add 6 or 7 c.c. of sulphuric acid, sp. gr. 1.84, and put an inverted crucible cover over the flask so that there is an atmosphere of carbon-dioxide over the solution. Put on the fire and keep at the boiling point until all the iron is in solution. Remove the flask, keeping the cover on, and cool the solution under running water. Now remove the cover, rinse down the sides of the flask with water and titrate at once with the permanganate solution. When the ferrous sulphate is all oxidized, one drop of permanganate will give a slight but permanent pink color to the solution. Observe the amount of permanganate solution used. From the reading obtained, the equivalent of one cubic centimeter of permanganate solution in iron can be calculated.

The solutions used in the iron analysis are made up according to Blair.

Mercuric Chloride Solution.

Dissolve 50 grams of mercuric chloride in one liter of water and filter.

Phosphoric Acid Solution.

Dissolve 200 grams of crystallized manganous sulphate in one liter of water. Add a few drops of sulphuric acid and filter. Add to this one liter of phosphoric acid, sp. gr. 1.3, 600 c.c. of water and 400 c.c. of sulphuric acid, sp. gr. 1.84.

Antimony Determination.

Take a 5-gram sample. If the brass is low in tin, add some pure tin, otherwise the antimony will not be completely precipitated. Dissolve in 50 c.c. of nitric acid, sp. gr. 1.20. Evaporate the solution to about 10 or 12 c.c. and then dilute to about 350 c.c. in a 500-c.c. Erlenmeyer flask. Boil for about 10 minutes and then let it settle with the flask at an angle of 45 deg. When the solution has settled well, carefully decant as much of the solution as possible, but do not lose any of the precipi-

tate. If the precipitate does not settle out well, decant through a filter paper and return the precipitate and paper to the flask. The presence of the paper will not have any effect on the titration. If much copper is present, add 300 c.c. of hot water, and let it settle as before and decant again. The object is to get rid of most of the copper. Add 15 c.c. of concentrated sulphuric acid and 4 or 5 grams of potassium sulphate to the flask and evaporate to white fumes. Then add $\frac{1}{2}$ gram of powdered tartaric acid. Heat quite strongly over asbestos until all the organic matter is dissolved. This can be told by the solution turning white or very light colored. This leaves the antimony and tin in the proper states of oxidation. Cool. Add 50 c.c. of water and 10 c.c. of hydrochloric acid, sp. gr. 1.20, and heat to solution of all that is soluble. Cool very thoroughly, using ice if obtainable. Add 120 c.c. more water and 10 to 12 c.c. more hydrochloric acid. Cool again, and then titrate with potassium permanganate solution.

The end point is distinct, but it fades quite quickly, so do not add more permanganate. The presence of more hydrochloric acid causes the end point to be hard to find.

The standard permanganate solution must be standardized by C. P. antimony, then the personal error in the end point here will be the same as in the regular antimony determination. In this way all errors in readings are eliminated. Otherwise, the antimony determination will probably be too high. Calculate the percentage of antimony present. Multiply the weight of antimony by 1.2658 and subtract it from the weight of SnO_2 and Sb_2O_3 as weighed up in the tin determination. The difference multiplied by 0.7881 equals tin.

Standardization of Permanganate Solution by Antimony.

The method used is that of Low* and is carried out as follows: Take 0.1202 grams of C. P. antimony and 0.1190 grams of C. P. tin. Put in a 500-c.c. Erlenmeyer flask and add 10 c.c. sulphuric acid, sp. gr. 1.84, and 3 or 4 grams of potassium sulphate. Heat until the metals are in solution or until the alloy is decomposed and all separated sulphur boiled off. Do not drive off all sulphuric acid. Do not let the melt get hard on cooling. About 7 to 10 c.c. is enough. Cool. Add 50 c.c. of water and 10 c.c. of hydrochloric acid, sp. gr. 1.20, and heat to get all possible into solution. (A little tartaric acid may be added here, but it is not necessary for so small amount of antimony as is present here.) Cool the solution, and add about 110 c.c. more water and 20 c.c. more of hydrochloric acid, sp. gr. 1.20. Cool very thoroughly, and titrate at once with potassium permanganate.

Arsenic Determination—Distillation Method.

Dissolve 20 grams of ferrous oxide (Fe_2O_3) in 150 c.c. strong hydrochloric acid. Boil for 10 or 15 minutes. Put in a distillation flask with 10 grams of brass. Distill off the arsenic, or until the solution in the flask is quite thick. Dilute the distillate to about 300 c.c. Nearly neutralize with solid potassium hydroxide, keeping cool while adding the hydroxide. Finish neutralizing with sodium bi-carbonate. Titrate with $n/100$ iodine solution. The iodine solution ought to be standardized each time a determination is made if made on different days.

For the standardization, use 0.1 gram arsenous oxide (As_2O_3). Add 50 c.c. of water and an excess of potassium hydroxide. Make up the solution to exactly 500 c.c. and take one-tenth for a sample. Treat exactly as in the arsenic determination.

The arsenic determination is seldom made on brass; because its presence in such small quantities seems to have no deleterious effect on the alloy. This determination, however, is often made on virgin copper and this method can be used.

Remarks.

The details of analysis have been given in full for the benefit of many a man who is called upon to make the determinations without any practical experience in this one line. It is the firm belief of the writer that any man with a common amount of

technical training and reasonable ability can make the complete analysis of brass with accuracy without having to look up any references or go into the work half blindly due to the vagueness or incompleteness of methods.

Electrolytic determinations are becoming more widespread and finding broader application each year. Electrolytic methods are very applicable to the analysis of brass and the quicker the brass man puts in a laboratory with an electrical equipment the better. They are more accurate than other methods, and a great time saver.

It is the belief of many that the time will soon come when the chemist will be to the brass foundry what he is to the iron and steel works, an absolute necessity.

I am greatly indebted to Mr. W. M. Corse for many general suggestions that he has offered me while working out these methods, or adapting them to the analysis of brass, and for his kindness in looking over the manuscript.

The Production of Finished Iron Sheets and Tubes in One Operation.*

BY SHERARD COWPER-COLES.

Hitherto it has been the universal custom to produce iron or steel sheets, tubes, and wire by a process of smelting the iron, refining, cementation, annealing, rolling, or drawing. The object of the present paper is to describe an electrolytic process for making tubes, cylindrical vessels, sheets, and wire in one or two operations from crude or scrap iron, or direct from the ore, without the processes of smelting, rolling, or drawing, at a cost that has hitherto been thought impossible.

It is generally believed that iron and other metals refined by electrolysis are quite free from those impurities which are invariably associated with metals produced by a smelting process. Electrolytic iron can be obtained almost chemically pure when special precautions are taken, but even then, when the product is made to form the poles of an electric arc lamp and the spectrum is carefully examined, there is evidence of the presence of minute quantities of impurities.

One of the first, if not the first, to mention iron produced electrolytically, was Bockbushmann in 1846. He deposited on a copper matrix a plate of iron 150 millimeters square (5.9 inches) and 2 millimeters thick (0.079 inch).

In 1857 Feuquieres exhibited specimens of electrolytic iron at the Paris Exposition. Alfred Smee in his book on electrometallurgy, printed in 1851, makes the following remarks: "The reduction of iron, from a pecuniary point of view, is the very worst process in the whole range of electric metallurgy, for the metal is scarcely worth anything in comparison with others. Iron masters doubtless sleep in perfect security when they are told that from one equivalent of galvanic power derived from my battery, costing one-twentieth of a penny, 28 grains of iron are reduced, so that the reduction of one pound of iron, worth about a penny, would cost more than a shilling for the bare materials used in its production, added to the value of the metal. In this aspect of affairs not only the blast, but even the puddling and smelting furnaces, are likely to continue to send forth their pestiferous fumes by day and their pandemonium-looking flames by night, corrupting the atmosphere to the injury of vegetation, as well as to the detriment of the health of human beings."

Since Alfred Smee made this remark forty-seven years ago, great progress has been made, the cost of the electrolytic process having been reduced from over a shilling per pound for iron in a rough form, which required smelting and rolling, to about a halfpenny for iron obtained in a finished form capable of realizing the highest market value.

Up to the present time the process of electrodeposition of iron has been confined to the facing of engraved copper plates for fine printing, such as bank notes, as iron has the advantage

**Jour. Amer. Chem. Soc.*, Vol. 29, p. 66. This article contains directions for titrating for tin as well as antimony.

*A paper read at the September meeting of the Iron and Steel Institute. Abridged.

of being easily removed with acid when worn through, thus enabling the iron facing to be removed without damage to the copper plate.

Klein introduced a process in Russia for the production of iron electrotypes for bank-note printing—that is, the plates were made of solid electrolytic iron instead of being copper faced with iron. The electrolyte used was composed of ferrous and magnesium sulphates, a current density as low as 0.30 amperes per square decimeter being necessary, one and a half months being required to give a thickness of 2 millimetres (0.079 inches).*

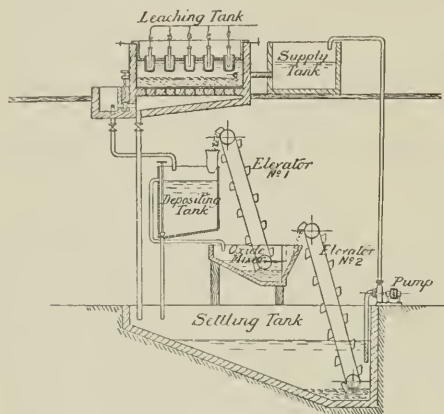


FIG. 1.—GENERAL ARRANGEMENT OF PLANT.

The author in the year 1898 made a number of experiments on the production of electrolytic iron plates, and produced plates of considerable thickness, but in such a rough condition that they required smelting and rolling; the rate of deposition, moreover, was so slow as to render the process impracticable, and it was not until the year 1900 that he succeeded in obtaining some small tubes.

The results obtained were a great advance on what had hitherto been effected, but were not far enough advanced to be turned to practical account; it was not until the present year that sheets and tubes were obtained of a quality equal to steel, and with a surface that required no after-treatment, such as rolling or drawing.

An electrolytic iron production process, to be of commercial value, must fulfil the following conditions: The voltage between the terminals of the depositing cell must be low, the current density per square foot of cathode surface must be high, and the iron or steel deposited must be in such a form that it can be used for industrial purposes without smelting. An electrolytic process that fulfils these conditions must revolutionize many branches of the iron trade, as it will enable thin iron tubes and sheets in particular to be produced at a very low cost, and without the necessity of burning coal.

The process briefly consists in placing crude iron (which may contain those elements which are at present so detrimental to the production of high-class iron or steel), or finely divided iron ore, in suitable containing vessels in which an acid solution is circulated using an insoluble anode material**; or, further,

*Mr. Cowper-Coles' paper gives here a series of tables of the e.m.f. required for iron refining with different electrolytes and at different temperatures. Concerning the electrolytic iron refining process of Burgess and Haanbuechen, see our vol. II, page 183.—Ed.

**Since it is stated later on that the crude iron or iron ore is connected to the positive pole of the electric circuit, it represents the real anode, and any "insoluble anode" which may be used must be in contact with the crude iron or iron ore, and serves simply for conducting the electric current to the latter. The description of the process, and especially the explanation of Fig. 1, is not very clear, though it is taken verbatim and in full from Mr. Cowper-Coles' paper. A further paper embodying the results of work now in progress is promised by the author for a future date.—Ed.

the process may combine the use of soluble and insoluble anodes. The crude iron or iron ore being in each case connected to the positive pole of a dynamo, the iron goes into solution, and is deposited on cylinders or plates which may be either rotated or stationary, depending upon the class of finished product required.

Fig. 1 represents the general arrangement of the apparatus employed when depositing iron from crude iron or the ore. In the former case the iron is arranged around the cathode, and in the latter insoluble anodes, of graphite, for example, a small electric current being employed to assist the leaching process.

It is conceivable that in some cases iron might be recovered without mining, acid liquor being circulated over the ore deposits. The process lends itself to the recovery of iron more especially from carbonated ores, "blue billy," Lake, and Bog ores. An electric process will no doubt prove to be a valuable adjunct where pig iron is used for precipitating copper, enabling the iron to be recovered instead of letting it run to waste.

Good results have been obtained from an ore containing:

	Per Ct.
Ferric oxide	50.7
Lime	3.8
Phosphoric acid	1.51
Alumina	10.0
Silica	16.0

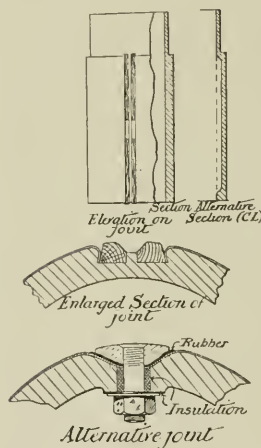


FIG. 2.—CONSTRUCTION OF CATHODE.

When it is desired to produce a highly finished sheet, a metal sheet of the desired surface is wrapped round the cathode, and held in position by means of grooves and wedges, as shown in Fig. 2.

In this way, sheets of large dimensions can be made; by employing a mandrel, say, 8 feet in diameter, a sheet 24 feet by 5 or 7 feet can be produced.

When it is desired to produce tubes, iron mandrels somewhat smaller than the internal diameter of the finished tube are coated with lead by electro-deposition, or by having lead drawn over them. Thus prepared, the mandrels are rotated in such an apparatus as is shown in Fig. 3. When the desired thickness of iron has been deposited, the mandrel is heated to a temperature sufficient to melt out the lead, and thus admit of its easy withdrawal.

The electrolyte employed consists of a 20 per cent. solution of sulpho-cresylic acid saturated with iron. Sulpho-cresylic acid is a cresol-sulphonic acid containing approximately 108 part of cresol and 98 parts of sulphuric acid. The cresol con-

tains ortho, 35 per cent.; meta, 40 per cent., and para 25 per cent. This cresol is heated with sulphuric acid, yielding isomeric cresol-sulphonic acids.

In some cases it is advantageous to add small quantities of carbon-disulphide, the temperature of the solution being about 70° C., the current density about 100 amperes per square foot. The solution is kept charged with iron oxide, which is kept in

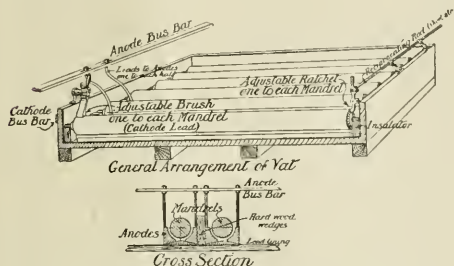


FIG. 3.—APPARATUS FOR DIRECT PRODUCTION OF TUBES.

suspension in the electrolyte by means of stirrers, by moving one or both of the electrodes, or by circulating by means of a bucket pump, as shown in Fig. 1. The specific gravity of the electrolyte having the iron oxide in suspension is about 1.32.

Excellent results have also been obtained by depositing the iron in a closed cell with a vacuum of a few inches, and also with a chloride solution and porous cells, bleaching powder being produced as a by-product; or the chlorine utilized to form fresh iron chloride.

The following are two typical analyses of electrolytic iron produced under the conditions described in this paper:

I.

	Per Cent.
Carbon (by combustion).....	0.060
Silicon	0.011
Sulphur	0.016
Phosphorus	0.041
Manganese	traces
Arsenic	0.004

II.

Combined carbon	under 0.05
Silicon	0.048
Sulphur	0.045
Phosphorus	0.04
Arsenic	0.01
Manganese	traces

A peculiar feature of electro-deposited iron is that it creeps to an extraordinary degree with a rounded, smooth edge over any material; in fact it is difficult to stop its spreading. Under certain conditions, when employing a rotating cathode, long tentacles form, 6 inches or more in length, in the direction of rotation with approximately the same curvature as the mandrel.

Amongst other applications the process can be applied to the production of bimetallic tubing and plates; that is to say, to tubes or sheets coated on the one side with copper or other metals or alloys.

The process can also be applied to the direct production of large sheets or strips representing the cutting surface of a file, and cut up into portions of the desired shapes, and secured to suitable backing, to form separate files. The prints are produced by making a continuous impression or a number of impressions from a suitable die, revolving roller, or reciprocating tool in a lead alloy. The matrix thus prepared is mounted on a revolving drum, and steel deposited by the process which has already been described.

Electrolytic steel, with considerable variation in the percent-

age of carbon, can also be produced. Houllevigue observed that when iron is deposited from iron containing uncombined carbon, the product at the cathode was free from carbon; but when deposited from iron containing combined carbon, the cathode product also contained carbon. The author's observations confirm this statement and at a future date he hopes to publish figures showing the results that can be obtained. The amount of silicon in the iron can also be considerably varied.

An important feature of the electrolytic process will no doubt be the introduction of some new ferro-alloys, which cannot be made by fusion. Alloys of iron and nickel have already been produced electrolytically.

Electrolytic iron sheets can be obtained with a highly finished surface, can be readily welded, coated with tin and zinc by dipping in a molten bath of these metals, coated with zinc by the Sherardizing process, or electro-galvanized.

The structure of electrolytic iron varies considerably; in some cases it is found to be amorphous, while in other instances it possesses a structure somewhat similar to that of wrought iron.

IRON AND HYDROGEN.

The properties of electrolytic iron appear to depend largely on the amount of hydrogen present, and therefore on the annealing, which reduces or eliminates the occluded hydrogen.

Samples tested have given a hysteresis loss of "under 0.3 watt per pound." The iron when charged with hydrogen is magnetic; and when magnetized, becomes a very powerful magnet as compared with ordinary steel.

Electrolytic iron always contains hydrogen in varying quantities, according to the conditions under which it is deposited, and the more hydrogen it contains the greater is its hardness.

The hardest varieties will scratch glass. Longheber has found electrolytic iron to contain 0.2 to 0.001 per cent. of hydrogen. Although these figures appear small when expressed as weight percentage, they represent volumes of hydrogen to iron of between 12 and 110. When high current densities were employed, deposits were obtained containing 110 times their own volume of the gas. Other investigators have obtained even larger percentages of hydrogen.

Electrolytic iron has a tendency, when deposited on a flat surface, to curve outwards—that is, it becomes concave relative to the anode surface when deposited on the cathode. There are two distinct varieties of electrolytic iron, with varying percentages of hydrogen; the softer kind of iron is silver-gray in color, whilst the other variety is very hard and brittle, breaking as readily as glass, and containing a higher percentage of hydrogen. The hardness varies between these two extremes. A surface can be obtained on the latter of a silvery whiteness, and with a mirror finish without polishing, as will be observed by the specimens exhibited. Either quality can be produced at will by increasing or decreasing the electromotive force at the terminals of the cell.

Iron highly charged with hydrogen is very inert, and not readily attacked by acids. The softer quality is also comparatively inert. Equal surfaces of wrought iron and electrolytic iron were immersed in pure hydrochloric acid, 2° Twaddell, for eighteen hours. The electrolytic iron lost 2.48 per cent. of its weight, and the wrought iron 13.13 per cent.

The temperature required for annealing electrolytic iron is slightly in excess of that required for ordinary rolled sheets. Electrolytic iron, when heated in a closed annealing box, gives off large quantities of hydrogen; and if a pipe is fitted to the annealing box the hydrogen flame can be kept burning during the whole process of annealing, and for a considerable time after the heat has been removed from the annealing box. This phenomenon has been turned to account for removing scale from ordinary rolled sheets by placing some sheets of electrolytic iron in an ordinary annealing box with plates to be scaled. Electrolytic iron gives up considerable quantities of its hydrogen under 100° C. without losing its brittleness, and also when boiled in water or oil.

When iron is deposited under magnetic conditions—that is, if a powerful magnet is placed behind the cathode—lines of magnetic force are obtained similar to those rendered visible with iron filings.

CONCLUSION.

The electrolytic production of iron and steel has now emerged from the laboratory or academic stage to a practical conception, enabling iron and steel to be produced in a highly finished form from iron ore or scrap iron, in a condition which realizes the highest market value, by a process which reduces labor to a minimum, and under conditions which can be compared to the working of a central electric light station for cleanliness and health.

In conclusion, the advantages may be summarized as follows:

1. Finished products, such as tubes, sheets and wire can be produced at less cost than by the processes of smelting, refining and rolling.
2. A product is obtained which does not corrode as readily as steel, at less cost.
3. The process can be worked economically when no coal is available.
4. Iron ore that is useless for ordinary smelting operations can be advantageously utilized by the electrical process.
5. The process is a power process, and utilizes but little labor. Small units can be worked economically.
6. The process is more cleanly and healthy than the operations of smelting.
7. Little or no scrap is formed.*

Electrolytic Gold Refining.

By EMIL WOHLWILL, PH. D.

In the March issue of this journal (Vol. VI, p. 114) Dr. J. W. Richards has calculated theoretically the requirements and results of the application of the electrolytic process of gold refining in a special case. In the present article I wish to present a few objections against some points of this calculation.

Dr. Richards chooses as example the electrolytic refining of an alloy containing 60.3 per cent gold, besides known quantities of silver, copper, lead, zinc, iron and nickel. He also assumes arbitrarily, it seems, certain conditions for the operation of the process. On the basis of theoretical considerations he then answers eight questions which are of importance for the practice. I assume that this example and its solution is intended to show to the practical man how to formulate and solve the problems, not only in this special case, but in other cases of gold refining. For this reason I like to present some objections against this special example and some of the assumptions and results.

I will first deal with the calculation of the interest charge, because it is of special importance for the gold refiner who wants to use the electrolytic process, and because it gives an opportunity to also refer to most other points. With anodes of the composition stated above and with the method of operation assumed by him, Dr. Richards obtains the result that the interest charge per kilogram of gold under treatment is 51 cents.

In the strictly scientific paper of Dr. Richards it is not said explicitly that this expense is so large as to prevent the practical refiner from using the process. Nevertheless, the practical man will look at this figure as the chief result of the calculation, if he is not cautious enough to examine carefully the calculation. That it is not free from slips will be seen. Thus the weight of the anodes is calculated from the assumed dimensions of the plates. The plates are 48 cm wide, 20 cm high and 2 cm thick. Since their specific gravity is assumed to be 17.5, each of these

plates weighs $48 \times 20 \times 2 \times 17.5 = 33,600$ grams or 33.6 kilograms. As five such plates are used in 10 tanks, the total weight of the anodes in the 10 tanks is $50 \times 33.6 = 1680$ kilograms. Dr. Richards finds and uses throughout 3360, i.e., double the real weight.

Further, the price of the kilogram of refined gold is assumed to be \$729. While such a high price for electrolytic gold might justify the high calculated interest charge, yet it is to be feared that even American dentists, who are said to prefer electrolytic gold, would not pay this price. According to recent information from Philadelphia, the Mint figure is a price of \$664 per kilogram of refined gold.

If we now substitute 1680 kilograms for 3360 and \$664 for \$729 in the calculation and if we calculate otherwise exactly as Dr. Richards does, we find the interest charge on gold stored in anodes and cathodes per kilogram of corroded gold as 28.5 cents instead of 51 cents.

But even this figure is found to be too high, if we revise the calculation further, without changing for the present anything in the assumptions. Dr. Richards obtains in 24 hours a deposit of 563.7 kilograms of pure gold, while in the same time only 304 kilograms gold are dissolved from the anodes. This gives a deficit of 259.7 kilograms of gold per day. Dr. Richards leaves it to his readers to consider the meaning of this deficit in the process.

Before we undertake to do this, it may be mentioned that the value found for the deficit is still too low. In calculating the ampere-seconds required to deposit 0.07 gram Pb, a multiplication sign, placed by mistake instead of a division sign, gives one error. Further, it is assumed that copper passes into the electrolyte as a monovalent ion, while it should be figured as a bivalent ion without any doubt. (Even if it dissolves at the anode as monovalent ion, the reaction $3 \text{Cu}' + \text{Au}'' = 3 \text{Cu}'' + \text{Au}$ will soon be active.) By making these two corrections, the daily deficit in the example becomes 285.9 kg of pure gold. That is, the deficit amounts to more than half of the 563.7 kg of gold which are to be deposited in 24 hours.

What does this mean? It means strictly that the process cannot be carried out in the way assumed in Dr. Richards' example. For it is impossible to deposit 563.7 kilograms of gold from a solution to which only 277.8 kilograms are added during the same time by solution from the anode. To render the process possible for the whole 24 hours, it is necessary to add to the electrolyte the deficit of 285.9 kilograms in some way.

This quantity of gold must be available from the beginning of the process, besides the calculated weight of the anodes, either as refined gold or in form of impure gold containing 38.5 kilograms of pure gold. This quantity must be brought into solution outside of the electrolytic tanks and must be gradually added in form of gold chloride to the electrolyte during the 24 hours of operation. This is to be repeated every day as long as the process is carried on.

It, therefore, becomes necessary to add to the interest charge, calculated before, the interest on 285.9 kilograms of pure gold. Nevertheless (under certain conditions) the interest charge for every kilogram of dissolved and deposited gold is not greater, but smaller than found before, since the \$118.60 of daily interest do not refer now to 304 kg (more correctly, 277.8), but to 563.7 kg of pure gold. The revised calculation, therefore, gives 21 cents instead of 51 cents per kilogram.

So far I have followed the methods of calculation exactly as made by Dr. Richards. But some of the data assumed by Dr. Richards I do not consider to be suitable. The impure gold anodes are assumed to have a thickness of 2 centimeters. This is well suited for copper plates, but in gold refining, if interest charge cuts a figure, it is too large, for the simple reason that, even with the high current density of 1000 amperes per square meter, a considerable part of these anodes is not dissolved by the current in 24 hours. This is, therefore, dead capital which only eats up interest.

*In an appendix to the paper the complete cost of plant for producing 500 tons of electrolytic iron in the form of tubes, sheets and wire per year (including cost of iron under treatment) is estimated at £108,295. The cost per ton of producing electrolytic iron tubes, sheets and wire is estimated at £5 13s. 3d., hence the cost per pound 1.2 cents. In this estimate the cost of the electric kilowatt hour is apparently assumed to be somewhat like 0.5 cent. The electric power cost is, under these conditions, little less than half the total cost of operation.—Ed.

If we make the anodes thinner so that they are consumed within 24 hours to as small a rest as possible, there will be a reduction of interest charge without any appreciable increase of other items of cost. Further, if we give to the starting sheets of the cathodes a thickness of 1/6 mm (which is quite sufficient) instead of 1 mm in Dr. Richards' example, the interest charge on the gold in the starting sheets is reduced to one-sixth.

With anodes and cathodes of such dimensions as used in practice, then with the same gold alloy, for which Dr. Richards makes the calculation, an interest charge of about 13 cents per kilogram of treated pure gold is found. It is unnecessary to give this calculation in detail, since I have already dealt with the calculation of interest in electrolytic gold refining in former articles in this journal (Vol. 11, pages 221 and 261). A small difference between the results given there and here is due to the different composition of the gold alloy to be refined.

It, therefore, follows that the high interest charge, found in Dr. Richards' example, is not inherent in the nature of the electrolytic process, but, besides some errors in calculation, it is due to the fact that the conditions of operation, assumed in this example, are unsuitable. There is an essential relation between the interest charge, found by Dr. Richards, and the thickness of plates, selected by him, and his numerical result does not represent a general disadvantage of the process in practice.

I am afraid that another erroneous impression may be obtained from the fact that among the first suppositions of Dr. Richards' calculation there is an assumption as to the current density to be used, without any explanation why this and no other current density is selected. The practical man might think that he was at liberty to choose his current density, so that he could enjoy all the advantages of as high a current density as possible. Experience would soon prove this to be a serious mistake.

If the alloy of Dr. Richards' example is treated as anode at the assumed current density of 1000 amperes per square meter, it will not be possible to continue the experiment for more than a few minutes. Awkward fumes of gaseous chlorine from the 10 tanks will soon indicate that the gold does not dissolve from the anodes; that the solutions lose their content of gold, and the voltmeter will show that the voltage is far from remaining within the moderate limits assumed in Dr. Richards' example.

The simple cause is that anodes containing 7 per cent silver and 7 per cent lead can be used only with current densities far below 1000 amperes per square meter, so that the process cannot be carried out as assumed by Dr. Richards. The refiner cannot select his current density ad libitum. The composition of the anode material, especially the content of lead and silver, determine the permissible maximum current density and, therefore, the whole arrangement of the operation, as is evident from Dr. Richards' calculation.

Before carrying out the theoretical calculation of the process, it is necessary in every case to consider what are the limitations due to the constitution of the anodes and how must the details of the process be arranged accordingly. If such a preliminary investigation is not made, the whole calculation rests on an unsafe foundation.

Finally, I will say a few words concerning the "deficit" of gold found in Dr. Richards' example. It means not only a high interest charge (this might be made up for by a higher platinum content in the gold), but the deficit leads with necessity to the bankruptcy of the process. Although Dr. Richards does not say so, it is easy to arrive at this conclusion.

We have seen that to cover the daily gold deficit in Dr. Richards' example, it is necessary to change 285.9 kilograms of gold daily (either as pure gold or as a gold alloy) into gold chloride outside of the electrolytic tanks. This will in general be done by dissolving the stated quantity of gold or gold alloy in aqua regia. If the same gold material is used for making this additional solution as is employed for making the anodes,

one has the advantage to treat about twice as much material as would be treated in the same time by electrolysis alone. But for the one-half of the material which is dissolved in aqua regia, we lose the essential advantage of the electrolytic refining process, which depends on the solution of the gold without the use of hydrochloric acid and without the development of gaseous chlorine. The cost, thus increased, is further increased by the additional work which is necessarily required.

The chloride solution thus produced must be freed from dissolved silver chloride and must then be concentrated to such a degree that it is possible to add it to the tanks. That this involves considerable difficulties is evident from the following calculation.

The object is to add 285.9 kilograms of gold in such a way to the tanks, that during the 24 hours of operation the original volume is not essentially increased. The 10 tanks of Dr. Richards contain originally together 600 liters of solution, and this volume must remain practically unchanged, while during the 24 hours a solution containing 285.9 kilograms of pure gold is added. If this gold solution is concentrated to such a degree that it contains 400 grams of pure gold per liter, it is necessary to add 715 liters of the strong additional solution to the 600 liters of original solution without changing the level of the solution. Evidently this would be possible only if during the 24 hours 715 liters of water would be removed from the tanks in form of steam. In view of the low temperature in the tanks and the small surface of evaporation, this evaporation could not be carried out in the tanks themselves, but would have to be done outside. This means another complication.

In view of this situation the older methods of refining would be preferable to the electrolytic process, if carried out as assumed with so much additional chemical operations which are rendered necessary by the gold deficit. Indeed, we have as a correlate to the gold deficit a quick increase of other impurities, and this means that we lose another advantage of the electrolytic process, when properly carried out, namely, the possibility of using the same electrolyte many times over and over again.

By treating the anode material of Dr. Richards electrolytically, 151 kilograms of impurities would pass into solution during 24 hours from the anodes. Another 155 kilograms of impurities would get into the solution as the result of adding at intervals new solution (made as described) to keep up the gold content. Hence, after 24 hours of electrolysis the 600 liters in the 10 tanks would contain, besides the gold solution, 306 kilograms of impurities or 598 kilograms of foreign chlorides in excess above those contained originally in the tanks.

It is unnecessary to say that it would be impossible to electrolyse again this solution, which would be more a mash than a liquid. Daily renewal of the electrolyte, daily treatment of the electrolyte left from the day before, are therefore other consequences of the deficit of gold. This means bankruptcy of the process.

I am not afraid that Dr. Richards might reply: "You say so." For it is evident that the serious disadvantages following from his calculation are not due to the electrolytic process of gold refining, but to the composition of the anode material, selected for the example. Not the electrolytic process is proven to be practically impossible by the calculation, but its application to an alloy of 60 per cent gold, 7 per cent silver and 33 per cent of other soluble metals. But to prove this it would not have been necessary to make the long calculation.

It would have been sufficient to make a preliminary investigation as to what alloys are suitable for the electrolytic refining process. Anybody familiar with the process would at once exclude all alloys containing so many foreign metals that the electrolyte loses all its contents of gold in half the time of operation and becomes simultaneously loaded with other metals to an extent as to be unsuitable for further use.

I do not overlook that the object of Dr. Richards' example is rather to show the general method by which to make such

theoretical calculations, and that only incidentally an alloy of unsuitable composition has been the subject of his calculation. But I doubt whether a practical man can make such calculations to his advantage without taking into account among other things the following points which I believe must be emphasized:

First, before employing the electrolytic gold refining process and before calculating its requirements and results, it is necessary to make a preliminary investigation whether the available raw gold alloy is suitable for electrolytic treatment, according to its composition.

Secondly, if the raw gold alloy is found to be suitable, it is necessary to decide on the conditions of operation, especially on the current density to be used, according to the composition of the anode material. This cannot be chosen at will, but the selection must be based on experience or theory (if there is a theory which answers this question).

Thirdly, if interest is to be charged for the gold, it is necessary and easy to modify the conditions of operation in such a way that the interest charge becomes a minimum.

Hamburg, Germany, August, 1908.

[Dr. Richards, to whom a copy of this article was sent, "wishes to express himself as being very well satisfied to have made the possible errors charged against him by Dr. Wohlwill in the above article, seeing that the present net result has been to clarify the subject for our readers and to have drawn from Dr. Wohlwill a lucid and masterly presentation of the inner facts and considerations concerned in the electrolytic refining of gold. Florence, Italy, Sept. 20, 1908."]

A Swiss Electric Furnace Steel Plant.

The machinery firm of Oehler & Co., at Aarau, Switzerland, are makers of steel and cast-iron machinery parts. They have a crucible steel plant of the ordinary kind, which has been replaced since August 1 of this year by a Girod arc furnace, with the most satisfactory results. An electric steel furnace plant of the induction type was started two years ago in Gurtellen, Switzerland, but the company has gone out of business. An electric furnace steel plant is in course of erection at Schaffhausen, Switzerland, based on the experiments of G. Fischer, but will probably be in operation before the close of 1908. Oehler & Co. claim, however, to have the credit of being the first successful electric steel foundry in Switzerland.

The company in question has acquired the patent rights to the Girod furnace in Switzerland. The Société Anonyme Electrometallurgique in Ugine (Savoy), of which Mr. Paul Girod is director, has at present four furnaces of two to eight tons capacity in operation, making ferro-alloys or ordinary fine steel. This company has 26,000 horsepower at its Savoy works.

The furnace erected for Oehler & Co. has a capacity of two tons, and requires 400 horse-power. Similar plants have been erected for the John Cockerill Society, in Belgium, for steel for military purposes; for Stoss in Stuttgart (Southern Germany), for fine steel castings, and for the Ternitz Steel Works in Austria, for machinery steel. The success of the furnace, and the commercial advantages of the process appear now to be beyond question.

In the Swiss plant at Aarau, the power is supplied by the Aarau City Electric Works, which utilizes a fall of the Aare, and has 3,000 to 4,000 horse-power at its disposal. It distributes power at 2,000 volts two-phase current, and sells it at the following prices:

55 centimes =	11	cents per kilowatt hour for lighting purposes
27 " =	5.4	" " " " " " motor " "
30 1/2 " =	0.6	" " " " " " smelting " "
	0.8	" " " " " " " "

The smelting rate is, therefore, taking the higher figure, 19.2 cents per kw.-day, of \$70 per kw.-year. Of course, the bill for energy consumption is based on the actual number of kw.-hours used, determined by meter.

The 2,000-volt two-phase current system supplies at the

Oehler works a motor of 450 horse-power, running at 560 revolutions, and coupled direct to a single-phase alternator, giving 4,600 to 5,000 amperes, single-phase current at 65 to 75 volts, the frequency being 37.4 periods per second. The use of the motor generator instead of a static transformer is interesting—without necessity.*

Twelve heavy copper cables, each 20 millimeters in diameter, and composed of 12 copper wires twisted together, carry the current 10 meters to the furnace. The voltage drop is 2.5 volts from the machine to furnace. The general features of the Girod furnace were described on page 428 of our last issue. The furnace is 2 meters inside diameter, 0.5 meter high, inside, and is electrically tipped and regulated. The automatic electrode regulator, by H. Cuénod, of Geneva, raises and lowers the electrode passing through the roof, so as to keep the current

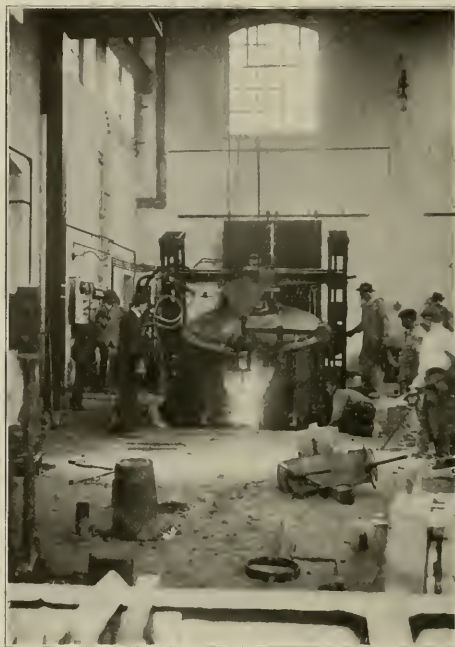


FIG. 1.—GIROD STEEL FURNACE AT OEHLER WORKS.

at the desired strength. The lining is stamped-in Styrian magnesite. The electrode is 350 mm. square by 1,500 mm. long, all in one piece. It weighs 200 kilograms at starting, and lasts sometimes to charges, but on the average 5 to 7. They come from the Girod works at Ugine (Savoy), and cost \$40 each.

In operation, charging takes about one hour, and when the current is turned on it takes 5 hours more, until the charge of 1,500 kilos is ready for pouring, with a current of 5,500 amperes at an average of 55 volts. At present two heats a day are run, but three could be easily obtained if the furnace were run continuously. A typical charge is:

*It is essentially impossible to transform from a balanced polyphase system to single phase by means of stationary transformers. As in one case we have a constant power flow, in the other case an intermittent one (see, for instance, Steinmetz's Alternating-Current Phenomena), the transforming apparatus must be able to store energy in a moment and give it off in another. That means, we must have revolving machinery. It seems not superfluous to emphasize this here, since attempts continue to be made and even to be patented to run a single-phase furnace from a polyphase system without unbalancing the latter.

Pig iron	265 kg.
Turnings	150 kg.
Scrap iron and steel.....	460 kg.
Return scrap	425 kg.
Lime	60 kg.

Besides these, varying quantities of ferro-manganese, ferro-silicon and aluminium are used, according to the needs of the charge.

A typical analysis of the steel, which is run into small castings, is:

Carbon	0.53 per cent.
Silicon	0.474 per cent.
Manganese	0.275 per cent.
Sulphur	0.017 per cent.
Phosphorus	Trace

Ninety-eight per cent of all castings are good, even in the case of the smallest and thinnest castings, and their long experience in making crucible-steel castings enables this firm to obtain castings as clear as ordinary foundry castings. The average tensile strength obtained is 55 to 65 kilograms per square millimeter (80 to 90,000 pounds per square inch), with elongation 5 to 10 per cent.

It is calculated that the electrical part of the plant has an



FIG. 2.—GIROD STEEL FURNACE AT OEHLER WORKS.

efficiency of 75 to 80 per cent; that is, that 75 to 80 per cent of the energy of the primary current appears as heat in the furnace. A rather approximate estimate of the calorific efficiency of the furnace itself, shows about 50 per cent of the energy of the current converted into useful heat.

The photographs show two views of the furnace in operation and about to be tapped, one into a hand ladle, the other into a crane-supported ladle. For the photographs and the information we are indebted to the kindness of Messrs. Oehler & Co.

Technical Thermometry.

By J. H. HART, Ph. D.

During the last few years great progress has been made in the science of thermometry, and manufacturers now realize the assistance that the physicist can give them in measuring temperatures which are of vital importance to them. In an immense number of industrial operations accurate temperature measurements are of the first importance.

The element of chance, so conspicuous and so costly in many operations, is nothing less than the element of ignorance, and progressive manufacturers in every phase of production are beginning to realize that where knowledge is obtainable guesswork is too expensive a system to tolerate. In many processes where the judgment of the temperature was previously by the eye of the workman, or in some equally vague or deceptive way, thermometers are now in regular use, saving serious loss from spoil work and material and effecting other considerable economies.

As an example of the widely varied practical application of the various electrical and radiation thermometers and pyrometers, the following may be mentioned: Annealing furnaces, boilers and superheaters, explosive sheds, porcelain kilns, hardening furnaces, brick kilns, hot blast mains, glass furnaces, casting and molding operations and many applications of ordinary temperature developments other than the extremely high or cold, and involving the active determination of temperatures at widely separated distances under variable mechanical conditions at one point at the same time. Under this head come large cold storage warehouses, with the accurate reading of thermometers in all the various boxes or cold storage rooms; breweries, chemical works, bakeries, hospitals, etc.

It is more especially the object here to consider the various types of thermometers available for utilization in molding and casting of the different metals, the principles back of these thermometers, their various advantages and disadvantages and their method of installation and cost, with operation and deterioration factors.

There are four different types of thermometers or pyrometers available for the measurement of comparatively high temperatures, and by high temperatures is meant those existing between slightly below red heat up to and including the melting point of iron. These types consist of electrical and radiation and absorption thermometers, the electrical thermometers being divided into two types, depending on the variation of electrical resistance with temperature and the production of a thermo-electric current, respectively.

The resistance thermometer consists essentially of a glass porcelain or platinum tube, enclosing a mica framework, around which is wound a platinum wire. These wires go out and can extend through flexible metallic tubing or otherwise to the recording devices, or to any measuring instrument situated at any point where the measurement is desired. The variation of the resistance of this wire with temperature for electric current is well known, and its resistance is measured by means of the Wheatstone bridge, an ordinary device for measuring resistance.

The principle back of the Wheatstone bridge is a comparatively simple one in electricity, but involves a number of operating details for the measurement of resistances under ordinary circumstances. However, its development has been such, in conjunction with the platinum thermometer, that the electrical recording device reads directly any temperature reading without the necessity of much adjustment and that of a purely mechanical character.

These porcelain tubes have four lead wires extending into them, two of these carrying the resistance wire, or measuring device, and the other merely serving to eliminate the error due to the heating of the leads and the variation in resistance of these with temperature. These tubes can be made of any length and have handles attached so that they can be inserted through

a suitable hole in the melting furnace, or into a pot of melted metal, and kept there constantly, recording the temperature until that desired for casting purposes is attained. They are, to all practical purposes, thermometers which are stuck into anything the temperature of which may be desired.

They can also be installed permanently at fixed points and can record the temperature at any time, or the temperature variation with time, by means of a recording drum or a recording disk.

These resistance thermometers have a wide range, from the lowest temperatures to 1200° C. or 2200° F. They can be placed in inaccessible positions and read from a considerable distance. They are extremely sensitive and respond quickly to changes in temperature. They can give direct readings of temperature, requiring no correction. They can furnish a visible record of temperatures varying from 10° or 20° , and the temperature can be read off without disturbing the records. By means of a switchboard a single indicator or recorder can be connected as desired to any number of thermometers. They represent probably the best type of thermometer, when action and reliability is considered, for all smelting, annealing and casting purposes.

The thermo-electric thermometers have many of the above advantages and, with special precautions, are as accurate as resistance thermometers. But they can be used up to much higher temperatures than resistance thermometers, namely, 1600° C. or 3000° F., and the temperature of a small quantity of a substance can be more readily measured. They are less costly to replace, and in their industrial form no battery is required, since they generate their own operating current. In conjunction with the millivoltmeter, they give direct readings of temperature, requiring no correction under ordinary temperature conditions.

The principle upon which they operate is based upon the fact that two different metals when in contact at two points generate an electric current around the system if one junction is hotter than the other. This phenomenon is known as thermo-electricity, and the average thermo-electric thermometer has its leading device or millivoltmeter so calibrated that they read accurate temperatures if the cold junction is kept at a constant temperature.

Some of these devices on the market use metals such that the ordinary climatic variations of temperature at the cold junctions require corrections which are negligible, and some types using less satisfactory materials for the production of the thermal electricity have a cold junction compensator, consisting of a mercury bulb, which by its expansion diminishes the resistance in the circuit and thus increases the action of the current in the millivoltmeter or diminishes it, as required. A suitable recorder can be used with this, and records from a number of thermometers can be obtained simultaneously on the same drum.

The radiation thermometers can be used from temperatures of about 500° C., or just below a red heat, up to the highest temperatures known. Since no part of this instrument is heated above 80° C., the life of this pyrometer is practically unlimited, whereas the deterioration of the other types, or of portions of the same, may be quite pronounced, since the thermometer part itself attains the temperature to be measured.

The radiation pyrometers, in conjunction with an electrical measuring instrument, give the direct readings of temperature, requiring no correction. They may or may not require a battery for their operation, depending upon whether they utilize the resistance or thermo-electricity principle in their interior, but in general, in the types on the market, no battery is required.

This thermometer is based upon the principle of the variation of the amount of radiation with temperature. According to what is known as Stefan's law, the amount of radiation given out from a body varies as the fourth power of the absolute temperature, and this law is exact as far as is known to science to-day. The thermometer consists of simply a telescope, which is sighted upon the body whose temperature is to be measured

and which reflects the radiation by means of a convex mirror on to a small thermo-electric junction, or small resistance wire, which becomes hot under the action of the radiation.

It is a remarkable condition that the relative position of this pyrometer with respect to a hot body whose temperature is to be measured can vary within wide limits without affecting the accuracy of the measurement. It has been found, for example, that the reading obtained for the temperature of a stream of molten steel was precisely the same 1200° C., whether the instrument was set up 3 ft. or 60 ft. away. The entire outfit consists of a telescope and a galvanometer.

The thermal couple in the interior of the telescope is heated by reflection from the mirror, and there are a comparatively few simple rules for its operation. Hence, the temperature can be obtained by simply looking at the metal through this telescope and taking the reading. The instrument is of special value for taking such high temperatures as those of molten steel, glass furnaces, brick kilns and electrical furnaces.

Its great flexibility and the readiness with which it is sighted enables it to be used for taking the temperature of metal in crucible just before pouring, thus ensuring correct casting temperatures, a point which is now known to be of special importance in the case of steel castings. It holds equally well for castings of all materials, since the temperature at which rapid cooling commences very greatly affects the microscopic structure of almost all alloys.

The Fery absorption pyrometer utilizes the same principle to the extent that the temperature measurement is based upon Stefan's law. A telescope is used and sighted upon the object whose temperature is desired. A small wedge-shaped, partially opaque prism is gradually inserted until the radiation from this substance is identical with that from a standard lamp, and the readings can be taken from the device operating the absorption wedge. It is of special importance in taking temperatures of very small bodies such as incandescent lamp films, high-temperature chemical reactions and laboratory work generally.

Of these devices the resistance thermometer is undoubtedly the most accurate and possesses the greatest sensibility. Small variations in temperature can be more readily measured, but the device is expensive and deteriorates with much greater rapidity than the other types, with the exception of the thermo-electric system. This latter, on the other hand, can be replaced readily and at much smaller expense.

However, absolute temperatures, or very accurate ones, are not especially essential in most industrial developments. The limitation of temperature variation in casting and melting of from 30° to 40° will result in a marked improvement in the character and uniformity of the product, since these temperature variations have formerly been of unknown amount and character.

A further limitation of the temperature within more restricted limits, while undoubtedly resulting in increased uniformity of product, are accomplished only by greater effort on the part of the operator, since the temperature varies considerably, under ordinary operating conditions, and the increased efficiency of production which results is not warranted by the outlay required for its maintenance. Thus the special advantages of the resistance thermometer are not essential for industrial progress. The thermo-electric and the Fery radiation thermometers are not only cheaper and easier to operate, but possess a much lower deterioration factor and as a general thing a much lower first cost. The absorption pyrometer as mentioned, while available, requires greater detail in its operation, with less accuracy in its reading than the other types. It is especially used, as has been said, in the determination of temperatures of very small bodies which could not otherwise be determined by any of the other types.

The radiation pyrometer possesses possibilities for its adaptation which will undoubtedly make it a strong competitor of the thermo-electric type. It is in reality a thermo-electric type, so

constructed that the junction does not enter the flame at all, and no part of the instrument becomes hotter than about 80° C. Its great range in adaptability, since it is essentially a portable device and can be carried from one part of the foundry to the other without having a flexible tubing connected with the thermometer for insertion, gives it a distinct advantage. However, in the pouring of molten metal its temperatures are not apt to be as exact as that involved in the insertion type, since the surface temperatures are always considerably less than that existing in the interior.

Some one of these types, whether of the practical or laboratory pattern, should be installed in every foundry and metal laboratory. Its utilization in research work and in the preparation of alloys and the detection of impurities compares very favorably with that of the most approved chemical analysis. In the preparation and examination of the new alloys, with the determination of heats of recalcence, its efficiency is unquestioned, and it is essentially an instrument of research in metallic investigation as important as that of any other device.

In the present state of foundry practice conditions are such that all save one can be held, by suitable care, in good control. That one condition is the temperature of the metal as it enters the mold. In no experiment has the influence of varying casting temperature failed to show, and none of the forms of after treatment such as annealing, rolling, etc., have brought the metal to the same uniform quality that the proper selection of temperature by this means has been able to accomplish.

Roasting Furnaces.

By OSKAR NAGEL, PH. D.

The usual roasting furnaces may be divided into the following general types: The hand-stirred reverberatory; the reverberatory with continuous discharge; the revolving cylinder with intermittent discharge; the revolving cylinder having continuous discharge; circular multiple-hearth shaft furnaces; muffle furnaces.

With these furnaces wood, coal, gas or oil can be used as fuel and all are intended for roasting crushed ore.

The ordinary hand-stirred reverberatory roasting furnace consists of a continuous hearth, covered by a low arch and having a fire-box at one end and a flue at the other. A furnace of this kind was illustrated in the February issue.

This furnace can often be economically built of stone, up to the half level, the rest of the structure being constructed of brick, the entire mass being bound together with T-rails or I-beams and wrought-iron tier rods. The hearth should be of sufficient area to suit the charge of the ore and tonnage required. The Allis-Chalmers Company builds them in sizes ranging from 7 by 10 feet to 17 by 72 feet.

A good example for a reverberatory with continuous discharge is the Brown roasting furnace, made by the Allis-Chalmers Company, and shown in Fig. 1. In its most improved form it is a single-hearth reverberatory, with an interior slotered wall on each side of the hearth, covered with a low arch. This roaster is made straight or round in shape, to suit local conditions. Fire-boxes, in number and position to suit the length of the furnace and the character of the ore, are provided. This furnace, in which stirring is done mechanically, is generally provided with an automatic ore feeder.

The Bruckner roaster, which consists of a revolving cylinder with intermittent discharge, was shown in the February issue. It is generally lined with fire brick, the cylinder resting on friction rollers and revolving between a fire-box and a flue.

The flame from the fire-box passes directly through the cylinder, and thence mixed with the gases from the ore, into a dust chamber. The cylinder is provided with manholes for receiving and discharging the ore, the latter being roasted in charges of several tons. The advantages of this type of roaster are that the charge of ore may be retained in the furnace as long as required, the heat can be nicely adjusted and the roasting can be completely and economically performed.

A circular multiple-hearth shaft furnace is the Stetefeldt roaster. It consists of a vertical brick shaft about 25 ft. high, having a fire-box nearer the bottom and a flue opening nearer the top; by means of a screw feeder, worked automatically, pulverized ore is continually sifted into the shaft, and, in falling through the heated air, which takes but a few seconds, it is roasted. There is also a fire-box placed at the bottom of the descending flue for roasting the flue dust.

The construction of the Wetthey roasting furnace, made by the Allis-Chalmers Co., is easily understood from Figs. 2 and 3.

The White-Howell roasting furnace, built by the Allis-Chalmers Company, and shown in Fig. 4, belongs to the type of revolving cylinder with continuous discharge.

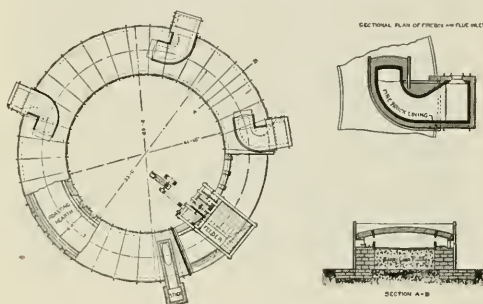


FIG. 1.—BROWN ROASTING FURNACE.

Roasting furnaces with a central shaft, with a number of circular shelves placed at right angles to it and with mechanical stirrers, are the Herreshoff roaster and the McDougall roaster. The latter, which is built by the Allis-Chalmers Company, is illustrated in Fig. 5. It is a vertical iron cylinder lined with brick; in it are 5 or 6 horizontal hearths constructed of brick. Through the center of the furnace and extending from top to bottom is a hollow water-cooled shaft. Directly connected to



FIG. 2.—WETTHEY ROASTING FURNACE.

the latter are hollow water-cooled horizontal arms, and to these are attached removable and adjustable rabbles.

The ore or matte, preferably reduced to $\frac{3}{4}$ in. or finer, is automatically fed into the uppermost hearth, and by the action of the rabbles it is carried toward the center, where it drops through an annular opening onto the next hearth. On the second hearth the rabbles feed the material gradually outward until it drops through marginal openings in the hearth onto the third hearth. The rabbles on the third hearth move the mate-

rial to the center, where it is discharged onto the next hearth, and so on throughout the furnace until it is delivered into a receiving hopper. The hollow central shaft and central arms of this type of furnace are provided with a water-cooling system, arranged for the circulation of water through the whole interior of same.

This furnace is suitable for roasting ores, concentrates of matte, which contain sufficient sulphur to roast of themselves, not requiring external heat. Ores carrying from 25 to 35 per cent sulphur can be roasted down to from 5 to 7 per cent of sulphur by their own heat alone.

For starting the roaster and for keeping it hot when it is shut down temporarily a circular fire-box is furnished, which is used in connection with two roasters. The usual construction is

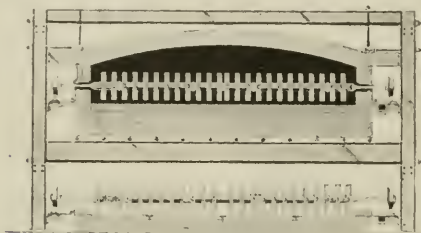


FIG. 3.—WETHEY ROASTING FURNACE.

to put in a fire-box for each two furnaces, simply for keeping up the heat should a shut down be necessary. For roasting non-combustible matter the fire-box is incorporated in the furnace, being placed under the lower hearth.

This roaster is suitable for roasting sulphide ores, the fumes from which are to be converted into a sulphuric acid. It is also in demand for roasting ores and mattes for subsequent smelting. The furnace, which is simple in construction, occupies but little space. The power required is from $1\frac{1}{2}$ to 2 hp. The speed with which the arms and rabblers revolve is determined by the degree of roasting required in the furnace and the

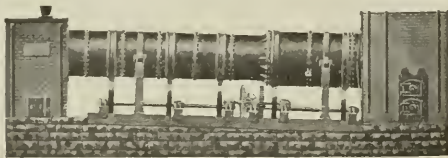


FIG. 4.—WHITE-HOWELL ROASTING FURNACE.

character of the ore. At Anaconda the shaft revolves once in $1\frac{1}{4}$ minutes.

In the Herreshoff roaster, built by the Nichols Copper Company (Fig. 6), two arms are attached to the shaft over each shelf, placed in opposite directions, having teeth or rakes so disposed on the first shelf that the roasting material is plowed from the shaft outward and delivered through openings at the outer edge of the shelf. As the ore drops on the shelf below the plows are so placed that the material is turned over and over, finally discharging through a large opening around the shaft. The area of this opening is sufficient for the gas that passes through it. The same is true of the openings at the outer edge of the shelf above.

The material after being plowed very slowly over five shelves, finally discharges through two outlets at the outer edge of the bottom shelf. The furnace has a very large vertical shaft, 14 in. in diameter, made hollow, so that a large quantity of air is drawn up through it; this amount being increased by the intro-

duction of a sheet iron stack extended above the top of the furnace.

Between the shelves there are cross-channels passing directly through the shaft at right angles. These channels are about 4

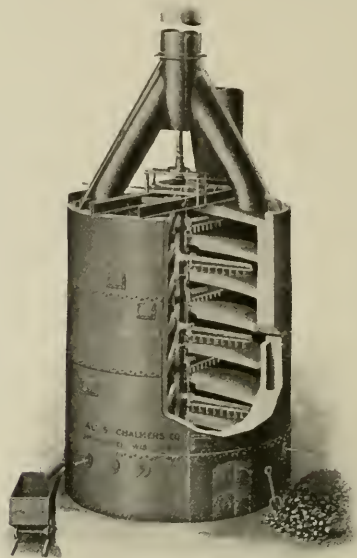


FIG. 5.—MC DOUGALL ROASTING FURNACE.

in. wide and 5 in. high and allow ample space around them for the passage of the ascending air. Into these channels or sockets the arms are inserted. In the top of each channel, at the center

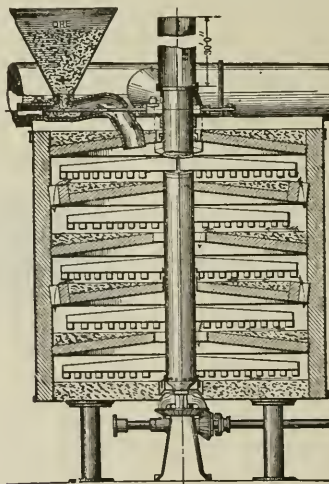


FIG. 6.—HERRESHOFF FURNACE.

of the vertical shaft, is a pocket running across the channel; into this a rib at the inner and top edge of the arm locks when the arm is forced into its proper position.

The weight of the arm always keeps it properly locked in the channel. By raising the outer end of the arm about 3 in. the top edge of the rib is brought below the pocket, and the arm can be easily pulled out. Practice has shown that these arms, weighing 100 lb., can be unlocked and removed from the furnace, and new ones put in and locked into place in about one minute.

Each furnace requires from one-tenth to one-quarter horsepower. The labor required is very small. At Butte 36 of these furnaces have been running for several years. For the control of their work one man only at each shift is required. The principal repair is due to the corroding or burning out of the arms. About six arms per year have to be renewed.

The ore is fed automatically, by means of a plunger that is

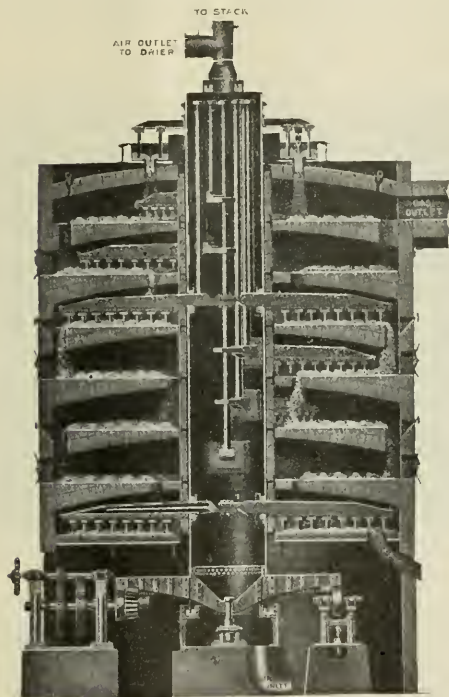


FIG. 7.—WEDGE SEVEN-FLOOR PYRITES ROASTER.

moved back and forth in a horizontal cylinder. When going toward the central shaft the ore is pushed forward and discharged down the curved pipe on the top shelf. When the plunger is pushed back, away from the central shaft, the fine ore descends and fills the vacant space. The mechanical device for the performance of this backward and forward movement is very simple. The central shaft revolves one revolution in two minutes, the plunger making two strokes in the same time. The usual amount of 44 per cent ore roasted in such a furnace is 7000 lb. The roasted ore contains from 2 to 3 per cent sulphur.

The central shaft, presenting a large cooling surface, modifies somewhat the temperature of the whole furnace. This is a decided benefit. That portion of the arm where greatest strength is, required is maintained below a red heat, as well as the shaft itself. The arms are hollow and of rectangular cross-section, and made of a composition, which stands the high heat satisfactorily.

Fig. 7 shows the Wedge roasting furnace, which is built by the Pennsylvania Salt Company. It is provided with a heavy shell and with vertical seams double-riveted. The shaft is protected with bricks on the outside. The arms are arranged to be cooled either with air or with water, according to the character of the material to be roasted. The arms last a very long time. The individual stirring blades are removable and, if one breaks, it can easily be replaced.

A Rotatable Zinc Furnace.

By GEORGE A. WETTENGEL.

The ordinary method of charging a zinc furnace is highly troublesome. Similarly the cleaning out of the red-hot retorts by means of water which turns to steam and blows out the residue is injurious to the retorts.

The following is a description of a furnace which does away with the processes of hand charging and blowing out:

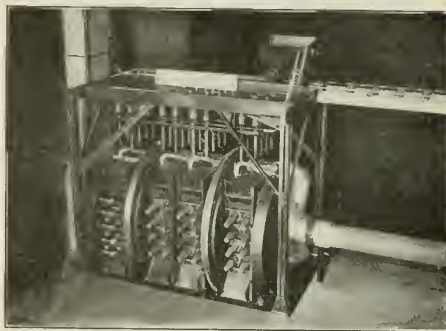


FIG. 1.—FRONT VIEW OF ZINC FURNACE IN OPERATING POSITION.

Fig. 1 is a front view of furnace in operating position. Fig. 2 shows the furnace in the charging position. Fig. 3 is a section through the furnace.

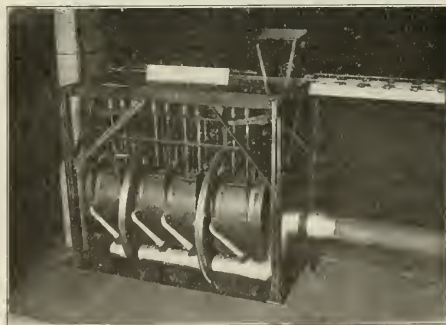


FIG. 2.—FURNACE IN CHARGING POSITION.

The furnace consists of a steel shell, with two tires supported on wheels. One tire has a gear attached, engaging a worm by which the furnace can be rotated to any desired position. The inside of the shell is lined with tile, with suitable shelves for supporting the retorts. The gas and air pipes are attached to and rotate with the furnace. The burners are placed in the back, top and bottom. Above the furnace is the charging floor, containing hoppers, each just large enough to charge one retort, with shut-off slides and telescopic spouts that are lowered to

the top of the retorts so that all the charge goes into the retorts. Below the furnace are hoppers for the residue.

The charging mixture is dumped onto the charging floor, each hopper filled, and the furnace is rotated upward so that the retorts are vertical and their open ends in line with the hopper spouts. These are now lowered, and slides opened, whereupon the charge falls by gravity into all the retorts simultaneously.

Then the furnace is rotated downward so that the retorts are now in a horizontal or any position which may be desired for the smelting operation. The condensers are put on, loamed, stuffed and vented. After the zinc is all taken out of the ore the condensers are removed and the furnace again rotated so that the retorts are again vertical, but have now their open ends downward. The residue then falls out by gravity into hoppers under the furnace.



FIG. 3.—SECTION THROUGH FURNACE.

The furnace is then rotated again so as to bring the retorts into a horizontal position and is then cleaned of loam and any remaining residue and recharged as before. But instead of rotating it to the position it occupied before, it is now rotated with the open end of the retorts pointing the opposite way. This inverts the retorts so that the bottom of each is used as the top and vice versa. This brings the slag uppermost in the retorts, so that it will melt and drip down on the smelting charge and go out into the pit on the next discharge.

This inverting of the retorts makes them practically self-cleaning, almost entirely avoids scraping, and doubles their life by using two sides. It keeps them practically straight. The method avoids the present danger of cracking of the retorts and of the slag eating holes clear through them, and it also avoids the injury to the red-hot retorts by blowing out with water.

Transmutation of Elements.—About a year ago Ramsay announced that he had observed the production of alkaline salts and lithium in solutions of copper salts, which had been submitted to the action of radium emanation. This suggested that a transmutation of elements had actually been observed. A repetition of these experiments with utmost care by Mrs. Curie and Miss Gleditsch, recorded in a recent issue of *Comptes Rendus*, has now given a negative result.

Roechling-Rodenhauser Induction Furnace for Three-Phase Currents.

An interesting novel development of the Roechling-Rodenhauser modification of the induction furnace (which was described in detail in our January issue, page 10 of the present volume), is described by Prof. B. NEUMANN in *Stahl und Eisen*, Aug. 12 and 19. The chief novel feature is that the furnace is operated by three-phase currents. A news item of considerable interest is the statement that in this furnace more than 1000 tons of steel rails have been made and sold to German railroads.

The original induction furnace required special electric generators because the requirement of a fairly satisfactory power factor* necessitated the use of a lower frequency than is used for lighting or power purposes in general. For the Kjellin furnace, with a charge of 500 kg, a frequency of 25 had to be used; for a 1500-kg furnace the frequency had to be reduced still further to 15.

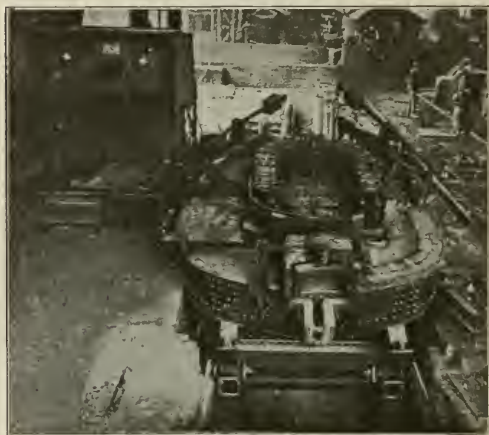


FIG. 1.—THREE-PHASE ROECHLING-RODENHAUSER INDUCTION FURNACE.

With the single-phase Roechling-Rodenhauser furnace, as described in our January issue, the power factor was already so far improved that 700-kg furnaces could be operated at 50 periods and 3-ton furnaces at 25 periods. But they still required expensive generators. This was a great disadvantage, especially with small installations.

With the new three-phase furnace this problem has been completely solved. The new 15-ton Roechling-Rodenhauser furnace is operated with currents of a frequency of 50 periods and is directly connected to the ordinary three-phase supply network of the Roechling steel works. Three-phase furnaces are now built for charges up to three tons for operation from a 50-period system, while with a frequency of 25 it is possible to increase the charge to 8 or 10 tons. The advantage of the three-phase furnace is chiefly due to the possibility of using standard three-phase generators, which do not demand an increased price.

Fig. 1 is an external view of a 1.5-ton three-phase furnace. Figs. 2, 3, 4 show sections. In its design the endeavor has been to approach as much as possible that of the open-hearth furnace.

A is the hearth; it is $\frac{1}{2}$ m wide and $1\frac{1}{2}$ m long. The three transformer cores are surrounded by the heating channels *R*. At the places where two such channels *R* enter into the main hearth *A*, the "pole-plates" (the special electrodes which are

*The ratio of watts to volt-amperes. The reason why it is important to have a high power-factor is explained in an editorial note in this issue.

the characteristic feature of the Roechling-Rodenhauser design) are provided. They are embedded in the furnace walls and between the pole-plates and the fused charge there is a refractory wall which is a good electric conductor when hot and then transmits the electric current to the charge.

Each of the three transformer cores is provided with a primary winding. Above each primary winding a secondary

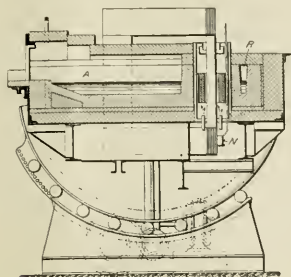


FIG. 2.—VERTICAL SECTION.

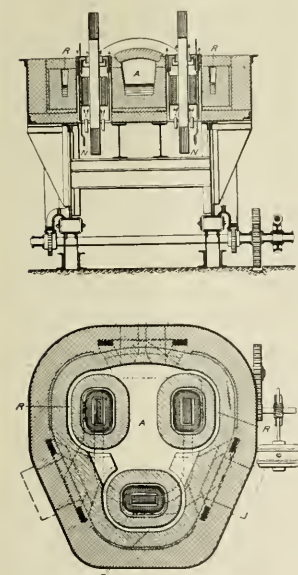
winding is also provided. While one end of the latter is connected to the busbar *N*, the other ends of the three windings are connected to the three "pole-plates." The furnace is built as a tilting furnace.

Concerning the metallurgical procedure, especially the removal of sulphur and phosphorus, the report contains nothing new, and the reader may be referred to the article on page 406 of our October issue.

A peculiar feature of the three-phase furnace is the rotation of the charge, due to the presence of a rotary field as in an induction motor. This means an excellent automatic circulation.

Some figures of analyses of samples taken from different places in the furnace are given to show the great regularity of the product in the manufacture of alloy steels.

For the production of steel rails, the electric steel is claimed to be superior to the open-hearth steel with respect to greater density and homogeneity. The open-hearth steel is first blown in the converter and then subjected to a brief refining process in the electric furnace, where the steel is allowed to stand and give off its gases.



FIGS. 3 AND 4.—VERTICAL AND HORIZONTAL SECTION.

Concerning power consumption, if the charge is introduced in liquid form, it is stated that the production of steel "of better open-hearth or crucible steel quality" requires during two hours of operation 200 to 300 kw-hours.

The voltage and ampere curves are almost straight lines, so

that the furnace does not show any sudden load variations which would seriously react on the supply network.

The furnace capacity is about 1.5 tons. With star connection the voltage is 400 to 420, and the current 380 to 400 amp per phase. Since the power per phase is 200 to 230 kw-hours, the power factor is between 0.75 and 0.8.

An estimate of cost, which relates, of course, to German conditions, and a brief comparison of different electrical furnaces is also given. "The following furnaces only need to be considered in practice: the electrode furnaces of Héroult, Girod, and Stassano and the induction furnaces of Roechling-Rodenhauser and Kjellin [Colby]. There is no such thing like a universal furnace. All that can be said is that one or the other furnace has special advantages or disadvantages for special purposes."

Notes on Electrochemistry and Metallurgy in Great Britain.

(From our Special Correspondent.)

The Study of Breakages.

September has been, as always, a quiet month so far as scientific meetings are concerned. The British Association held its meetings in Dublin during the first week of the month, and the Iron and Steel Institute met at Middlesborough during the last week. Other institutions are arranging their winter programs, which bid fair to be very heavy.

Of the British Association papers of special interest for these columns, mention must first be made of Mr. WALTER ROSENHAIN's paper on "The Study of Breakages." Mr. Rosenhain spoke as an apostle of investigation in regard to all breakage. Serious inquiry is seemingly reserved for those cases in which failure of materials has led to loss of life, in "the far greater number of cases, where the part in question is either of minor importance, or where the result is merely a temporary inconvenience which is rapidly forgotten, the question of the cause of the breakage is not, as a rule, examined with any great degree of care. Those immediately concerned no doubt form some idea of the cause, and endeavor to avoid its recurrence; but since the time and means at their disposal for such purposes are necessarily limited, while very frequently they do not possess that specialized knowledge which is required in such investigations, their conclusions are liable to be faulty, and such conclusions have in some cases become stereotyped into widely accepted but entirely mistaken views on the behavior of materials.

"Larger and more serious cases of failure or breakage often remain unstudied because the maker or manufacturer of the broken article sometimes prefers to accept the responsibility for the breakage, and to replace the broken object, provided that the matter is not investigated by experts. This attitude is apparently based on the view that, apart from the slight risk of publicity, expert investigation may lead to the establishment of more stringent tests or specifications. Actual experience of such investigations, however, shows that the recognition of the true cause of a failure is always of ultimate, and frequently of immediate service to the manufacturer of engineering materials."

Therefore Mr. Rosenhain proceeded to plead for a thorough investigation of cases of failure or breakage, pointing out that a frequent, and, indeed, nearly always an advisable, method of studying failures is to compare the broken article with a similar one which has given good service—this not only gives the investigator the means of applying the test of actual service to his conclusions, but incidentally it also throws valuable light on the relative importance of the various factors that are insisted upon by various specifications—and the effect upon the specifications is not by any means always in the direction of increased stringency.

It is not rare to find that material which from the point of view of the usual specifications would be regarded as superior

has failed, while material lying nearer to or even beyond the limits set by the specification has given good service. Of course, it is not suggested that any conclusions as to the correctness of the specifications should be drawn from isolated or even from a small number of instances of this kind, but the accumulation of such data, only derivable from a systematic study of breakages, would undoubtedly lead to a sounder appreciation of the relative importance of the various clauses of our specifications.

According to the stage at which the defect which has ultimately resulted in breakage has arisen, the causes of failure may be classed into three large groups:

Group 1.—Defects arising from the manufacture of the material of construction.

Group 2.—Defects arising from incorrect treatment of the material during the process of construction.

Group 3.—Defects arising during the life of the structure or machine.

The first of these groups is necessarily a very wide one, but if for the moment we confine our attention to the most widely used of our engineering materials—steel—a few of the more typical cases may be mentioned. Thus the material may be defective on account of the presence in it of undue quantities of impurities. Opinions differ widely as to what is to be regarded as "undue" in this respect, while the distribution of the impurities through the mass of metal is also of importance. The whole question of "segregation" and its relation to the soundness of steel arises in this connection, and is one of those which the systematic study of failures will gradually elucidate. It is obvious, however, that the investigator can arrive at a good idea of the nature of the material in this respect by means of chemical analyses of samples taken from different parts of the broken object.

The quality of the material as supplied by the maker is, however, obviously dependent upon other factors besides the simple question of correct chemical composition. Subsequent to its first manufacture into ingots the metal may have undergone deleterious treatment before passing on to the user. Thus the material—again in the case of steel—may have been overheated or even burned. The latter defect will be relatively easily recognized—the mechanical tests of the material will give bad results and microsections will at once reveal the cause, although in the case of metal which may have been heated by the user as well as by the original maker it will not always be possible to decide at which stage the damage was done.

Overheated steel is also readily recognized in the same way, but while the damage done by actual "burning" persists through all subsequent mechanical and thermal operations, the damage due to mere overheating can, it is believed, be undone by subsequent treatment. If this has actually occurred, it may happen that a piece here and there has escaped the refining operation and a weak piece comes through into the finished machine or structure. Such weak "patches" may be confined to quite small areas, so that careful investigation of the immediate vicinity of a fracture is essential to guard against overlooking such a point.

In many cases the manufacturer of the steel (or other metal) supplies it to the user in a partially finished form, such as forgings ready for machining. In that case the conduct of the forging and annealing operations may become a source of weakness; insufficient working by press or hammer, finishing at too high or at an excessively low temperature, and possibly imperfectly welded places where scale has been worked into the metal, may all give rise to subsequent failure. Again, unequal heating or cooling of large pieces of metal, and insufficient or unduly prolonged annealing, may also be mentioned. Such cases can generally be recognized by means of the microscope, great diversity of structure between different parts of the same forging being a very characteristic indication of some of the defects just named.

Such processes as punching or shearing, if at all carelessly

performed, or used in an improper manner as substitutes for more satisfactory but more expensive processes, may give rise to more or less unsuspected weaknesses. Thus, for example, the great ductility of mild steel naturally suggests that a considerable amount of cold working can be done without impairing its strength materially; but actual results have shown that cold working, particularly if applied at all locally, may be an exceedingly dangerous proceeding. It appears to be possible to entirely exhaust or destroy the ductility of a small portion of the metal if cold work is applied to it without proper precautions, and the local brittleness thus induced may result in the failure of the entire piece. Thus the hardened and brittle region which is produced when a plate is sheared in a bad shearing machine will cause the entire plate to crack across quite readily, and many other similar examples might be cited.

From the point of view of the investigation of breakages, the occurrence of undesirable cold working can generally be subsequently detected by the presence in the metal of regions of severe deformation. These are readily detected by the aid of the microscope, while mechanical tests reveal the local brittleness of the material at such points.

Turning to Group 3, we find a certain number of cases in which the most careful investigation can find no sign either of inherent defects in the material or of any injurious treatment during manufacture or construction: in these cases the metal has generally been subjected to undue stresses while actually in use, and has thus failed in the ordinary course of events. Actual faulty design—i.e., design imposing known, but unduly severe, stresses on sound material—is probably one of the rarest of such causes; but there are a number of others which come properly under this head, and these certainly occur at times.

Thus small errors in erection may at times throw undue stresses on certain parts—i.e., the design, either through inefficient construction or on account of its inherent difficulty, may not be correctly carried out. Probably more frequent, and therefore more serious are the operations of forces which do not readily lend themselves to calculation; as examples of the class of cases referred to, we may take the effects of thermal expansion and contraction arising in the case of steam boilers, and to a lesser extent in all heat engines. If by this or any other cause bearings are thrown out of line to a very slight extent, the alternating stresses that may be set up are often sufficient to account for the breakage of one of the parts concerned.

In investigating these cases one very useful line of evidence is obtainable from a study of the fracture itself; the details of the fractures of steel under various types of loading, as by direct tension, shock, alternate bending, etc., show characteristic differences, and a close examination of the fracture—if it is available in a sufficiently well preserved condition—will often enable the investigator to decide in what manner the breakage occurred. Beyond this he has, as a rule, only negative evidence to go upon; but if his study of the material of the broken part leads to the conclusion that the material was sound, then at least the manufacturer of the material is relieved from blame in the matter.

The paper concludes with four typical examples of failures with details of their investigation. The first was of the inner tube of a large gun which developed internal cracks and ultimately fissured completely after an abnormally short life. Tensile tests, alternating stress tests, and impact tests were made, as also detailed micrographic examinations, and the following summarized general conclusions deduced:

"The microscopic evidence, when correlated with the results of the mechanical tests, leads to the conclusion that as regards general composition, heat treatment, and mechanical treatment, the steel of the fractured gun-tube is normal, but that its strength is perceptibly impaired by the presence in its mass of a very large number of slag enclosures. The presence of these foreign bodies particularly reduces the power of the steel to

resist cracking transversely to the direction of forging, and the presence of longitudinal cracks in the tube is in accordance with this view."

The second case was that of the flanged plate of a thermal storage drum, which is now notorious in the annals of the English boiler explosions. This failure was due to severe strains set up by unduly hard cold working at the boiler maker's.

The third case was that of a locomotive crank pin which broke off in service with an apparently clean fairly smooth fracture. Mechanical tests, microscopic examinations and chemical analyses were made, with the result that it was proved that material which was originally of a satisfactory character had been spoiled by too severe a hardening process, and failed by a spreading of the hardening cracks which had thus been formed.

The fourth example described was that of a large shaft, intended to run at a high speed and to transmit a large amount of power; this shaft ran satisfactorily for some time, but ultimately fractured through a portion 12 in. in diameter. The fracture itself was peculiar in showing an outer ring, a little over an inch wide, which appeared rusty when the whole broke; this outer portion of the fracture was very smooth and fine-grained, but the central portions of the shaft had broken with a very rough, coarse-grained fracture. This was found to be a case in which steel of perfectly satisfactory composition has been put into use in a thoroughly unsatisfactory condition, and there can be little doubt from the evidence described above that the cause of this bad condition lay in the treatment received by the steel during the forging process.

The coarsely crystalline condition of the center of the shaft is one that has either persisted from the original coarse structure of the ingot, owing to insufficient work being put upon the piece during the forging, or it might—less probably—have been produced by considerable overheating, followed by a somewhat sudden cooling of the outside of the shaft. The latter conditions are unlikely to arise in ordinary forge operations, so that the former explanation remains as most probably correct. There can be no doubt at all that the coarse structure of the center of this shaft was present in the steel as supplied by the manufacturer, and cannot have been produced as the result of vibration or working stresses.

The description of these actual cases is certainly interesting and should serve to show the extent to which the application of modern methods renders possible the detection of causes of apparently mysterious failures. No doubt, cases may arise from time to time which baffle the resources of the investigator, but under favorable conditions considerable insight into such cases can be gained. These favorable conditions, which can often be realized by careful attention on the part of those under whose authority the fracture has occurred, may be summed up as follows:

1. Full information as to the exact circumstances of the failure, the service already undergone by the part in question, its origin, and any special circumstances concerning it.
2. Careful preservation of the fracture itself and of all portions of the fractured part, in order to avoid the covering up of important facts by the rapid accretion of dirt and rust which so frequently occurs.

* * *

The discussion of Mr. Rosenhain's paper was opened by Sir William White, who said that every engineer he thought would agree with the general statement that every failure should be thoroughly investigated, and would also agree that as a result highly valuable improvements in practice might be effected. At the same time, every engineer was better pleased when the failure was somebody else's, and still more pleased when that somebody would allow the publication of full details of the investigation. Here, however, the existence of the National Physical Laboratory removed many difficulties to such publications, as they might be safely relied on to treat the matter confidentially, and prevent names involved from becom-

ing public property. Coming to Mr. Rosenhain's suggestion that a thorough investigation might fix the separate responsibility for a fracture of the maker and the user, he would say that the user should be protected by a specification, providing that the metal furnished should receive only the usual treatment. That indeed was what these specifications were for. Thirty-five years ago, when they had begun to use mild steel for ship-building, it was his duty to draw up regulations governing both the manufacture of the metal and its subsequent treatment in the Government dockyards. Little was known at the time, and in the early days some very unpleasant discoveries were made; but in three or four years only things settled down to a practice, which, though subsequently improved on, had not been materially altered since. He was himself certain that no user or manufacturer would desire to keep secret knowledge which would lead to improved methods; provided only that in furnishing such data he should be put to no commercial disadvantage. The advancement of science was, no doubt, an admirable object, but business considerations were imperative.

The only other speech of importance was that of Captain H. Riall Sankey, who congratulated Mr. Rosenhain on the production of so valuable a paper. In this, however, the author had, of course, not dealt with every dangerous method of treating steel, among which the speaker considered continued forging at a low heat of an overheated forging particularly dangerous. If steel were heated above a temperature of 1200 deg. Cent. it took a coarsely crystalline structure, which gave a lower tensile test than properly treated steel. If such an overheated steel were afterward forged at too low a heat, this coarse crystalline structure was broken up, but the metal was rendered very brittle, as had been shown by Dr. Stanton's impact tests, and by the speaker's own bending machine. He thought that many of the so-called mysterious fractures originated thus—viz., by a forging being overheated and finally finished off at too low a heat. If such overheating did occur, the forging before being put into use should be annealed at 900 deg. Cent. and quenched, a procedure which, as Mr. Stead had shown, broke up the coarse crystals and produced a reliable metal.

In reply to the discussion Mr. Rosenhain said that the difficulty with respect to Sir William White's suggestion, that specifications should call for the ordinary treatment of steel, was to fix what this ordinary treatment should be. Not long ago the hammer dressing of plates constituted ordinary treatment. If a bulged plate came in, the bulge was taken out by cold hammering, which, it was considered, could not damage a material showing a 20 per cent elongation on 8 in. It was now recognized, however, that such hammering was most injurious. In short, the margin between the treatment which was perfectly safe and one which was dangerous was very narrow. He did not, of course, pretend to deal in his paper with all possible causes of failure; but referring to Captain Sankey's remarks on the danger of forging overheated metal at too low a temperature, he thought that the real remedy was "not to overheat the metal." The question as to whether steel heated beyond 1200 deg. Cent. could have its structure restored by annealing was a very open one. Personally, he was inclined to agree with Mr. Stead that the remedy was effective, but there were many who maintained that a steel once rendered brittle by overheating could not be restored by annealing. In any case there was a danger that some patch might escape being cooled sufficiently rapidly in the final quenching; and in examining fracture it was very necessary to look for evidences of this, of which he had come across several instances.

Electro-Analysis.

Also, at the British Association, Dr. HENRY J. S. SAND gave a demonstration of a process of electro-analysis, in which the principle of a very vigorous stirring of the electrolyte has been combined with that of keeping the potential of the cathode under control by means of an auxiliary electrode. It has thus

been possible very largely to extend the scope of electro-analytical methods. The following metals have hitherto been studied. First the metals of the silver and copper groups and zinc, i.e., silver, mercury, copper, bismuth, lead, cadmium, and zinc. These metals have all been deposited singly, separated from each other and also separated when all present in the same solution. In the last-named case the quantity of each metal taken varied between 0.10 and 0.15 grammes, and the time for the deposition of each between about 10 and 15 minutes. Secondly, new methods have been elaborated for the determination and separation from each other of antimony and tin. A considerable number of determinations have been carried out in which the metals taken in varying ratios weighed together approximately one gramme. The time for the deposition of the antimony was usually about 20 minutes, that for the tin about 80 minutes. Lastly, the possibility has been examined of securing a purely electro-analytical method for the analysis of an alloy consisting of copper, antimony, lead, and tin, and all the separations required for such an analysis have at the present time been carried out.

Dr. F. MOLLWO PERKIN and Mr. W. HUGHES also contributed a paper on this subject and showed two forms of apparatus for the same purpose as that of Dr. Sand. In the one case a rotating cathode in the form of an elongated thimble is used, a platinum gauze cylinder acting as anode; and in the other case a spiral anode of platinum is employed, and a gauze cylinder serves as cathode. It was also shown how this apparatus could be used for depositions by means of the graded potentials when an auxiliary electrode is employed to maintain a constant potential.

Parabolic Reflectors.

Mr. SHERARD COWPER-COLES described his method for the production of true metallic surfaces for parabolic reflectors, in which the mirrors are deposited electrolytically on a carefully ground glass mold. The preparation of this mold is a long and costly operation, but when once prepared the reflecting surface can be reproduced in metal any number of times at a fraction of the cost, thus enabling mirrors of a true parabolic curve to be manufactured at a very cheap rate. The mold is coated with a thin film of silver on the convex side by a chemical process, and mounted in a metallic ring, which makes contact with the silver film, and is then suspended with the convex side downward on a spindle, placed above an electrolytic cell for depositing copper. The spindle is rotated at 5 to 10 revolutions per minute, while the copper is being deposited on the silver coating until a sufficient thickness has been obtained to give the necessary rigidity. The glass mold and copper deposit is then placed in warm water and gradually heated until the expansion of the copper causes it to leave the glass mold. The mirror thus produced has a surface as highly polished as the glass, and of exactly the same curvature. A silver-faced mirror thus produced would tarnish and be scratched too readily for practical purposes, so it has to be faced with some harder untarnishable metal or alloy. The metals usually employed for this purpose are platinum, palladium, or an alloy of silver and cadmium, which are deposited in a bright form.

The Ionic Theory.

Professor ARMSTRONG is still among the unconverted, and therefore in opening a discussion on the ionic theory at the British Association, it is not surprising to still find him a hostile critic. He started by saying that the assumption of independent ions in solution had not been experimentally proved, and he did not believe that hydrochloric acid, for example, was dissociated in aqueous solution into H cations and Cl anions, but that in contra-distinction to dissociation there is an association between the water molecules and hydrochloric acid in solution



and he considers that when an e.m.f. acts, it is sufficient to break down this unstable molecular complex, and then the chlorine will be carried to the one pole and hydrogen to the other. He likewise affirmed that there was no proof and no probability that water itself was to a certain extent dissociated into H and OH ions.

In the discussion which followed, Sir Oliver Lodge remarked that physicists had no objection to imagining hydrations of ions. They also had no particular objection to the formula for hydrochloric acid in solution which had been put upon the board. Armstrong was getting nearer to the physical chemist than he had ever done before. Sir William Ramsay remarked that as all mention of electrons had been omitted it was hardly possible to discuss the question because chemists looked upon electrons as constituents of ions. Prof. Armstrong considered that this only added to the confusion.

SYNOPSIS OF CURRENT LITERATURE.

Electrochemistry.

Fundamental Units.—The National Physical Laboratory (Great Britain) has presented through the British Association at its Dublin meeting a complete set of "Specifications for the Practical Realization of the International Ohm and the International Ampere, and Instruction for the Preparation of the Weston Standard Cell." These specifications will be brought up at the London meeting of the international committee on electrical units for adoption. They are published in detail in the Sept. 18 number of *The Electrician* (London), from which are taken verbatim the directions concerning the production of the international ohm, this having never been published before.

The international ohm shall be the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice, 14.4521 grams in mass, of a constant cross-sectional area, and 106.300 cm in length, arranged in accordance with the following specifications. The column of mercury shall be of constant cross-section or nearly so, and shall be contained in a glass tube of suitable composition, which has been carefully annealed. The tube shall be straight to the eye, and the maximum variation in its area of cross-section shall not exceed 2 parts in 100. The tube is to be carefully calibrated, and the correction for its conicality carefully determined. In determining the weight of mercury contained in the tube when filled at the temperature of melting ice, the column of mercury is to be bounded by planes at the terminal cross-section of the tube. The tube should not be unduly heated, and it should be filled with mercury by the exhaustion of the air. The axial length of the tube should be measured at 0° C., if possible, otherwise the coefficient of expansion of the glass determined and the axial length of the tube at 0° C. calculated from axial measurements made very near that temperature. To facilitate axial measurements of the tube, the ends of the tube should be ground very slightly convex. For electrical measurements the ends of the tube are to be connected to spherical bulbs of glass, the slightly convex ends of the tube forming, very nearly, portions of the internal spherical surfaces of the bulbs. Each bulb is to be provided with a current and a potential lead, the point of entry of the former and the end of the tube being at opposite ends of a diameter of the bulb. The potential lead shall be situated in a plane midway between the point of entry of the current lead and the end of the tube, and at right angles to the line connecting them. Contact with the mercury shall be made by means of platinum wires. The diameter of the bulb shall be from 30 to 33 times the diameter of the terminating section of the end of the tube to which it is to be connected.

If L is the axial length in centimeters of the mercury column contained in the tube at 0° C., W the weight of the mercury in the column in grams, and μ the correction for conicality of the tube, the resistance of the column at 0° C. is

$$\frac{L^2}{(106.300)^2} \cdot \frac{14.4521}{W} = 0.001278982 \mu \frac{L^2}{W} \text{ international ohms.}$$

Where the spherical bulbs are fitted to the ends of the tube and the whole filled with mercury, if r is the mean radius of the tube and r_1 and r_2 the mean radii in centimeters of the terminal sections, the resistance at 0° C. between the potential leads is

$$0.001278982 \frac{L^2}{W^2} \left\{ u + 0.80r^2 \frac{(r_1 + r_2/r_1 r_2)}{L} \right\} \text{ international ohms.}$$

Correct to 1 per cent of the added resistance

$$0.001278982 \frac{L}{W^2} \left\{ 0.80r^2 (r_1 + r_2/r_1 r_2) \right\}$$

The factor 0.80 has been assumed tentatively; it will later be fixed at the Congress of Units.

The electrical measurements are to be carried out at 0° C., the tube and spherical vessels being surrounded by melting ice and about 15 centimeters below the surface of the ice. The connecting wires employed for the current and potential leads must be thin, the flow of heat through them to the mercury being insufficient to warm the mercury so as to produce an appreciable error. The insulation resistance between the mercury column and the ice surrounding the tube must be no less than 10,000,000 ohms. The current employed in comparing the mercury resistance with the other resistances shall be limited by the condition that the mercury shall not be warmed sufficiently to produce appreciable error. The mean of at least five tubes must be taken to determine the value of the mercury unit. The mean of at least three fillings shall be taken as the value of the resistance of a tube.

Cadmium Cell.—R. Jonast has made some researches on the "Influence of temperature on the e.m.f. of the cadmium cell." The original appeared in *Comptes Rendus*, only a translation of which appears in the *London Electrician* of Sept. 18. The formula, given by Jager and Lindeck, $E_t = E_{20} - 0.000038(t - 20) - 0.00000065(t - 20)^2$, is applicable down to 0° C. for cells whose negative electrode consists of an amalgam containing 12 or 13 per cent cadmium. Some cells containing a 14 per cent amalgam showed irregularities as great as several ten-thousandths of a volt in the neighborhood of zero. A series of experiments made in the Laboratory d'Electricite showed that with cells containing a 12.5 per cent amalgam the e.m.f. at 0° C. was about one ten-thousandth of a volt less than that indicated by the formula. The formula does not, however, apply to cells containing a 10 per cent amalgam. They agree closely with the value given by the formula at 10° C., but at zero differ between themselves and are higher than indicated by the formula by as much as one-thousandth of a volt. No explanation of this apparent difference and also of the slow attainment of a constant value of these 10 per cent cells is given, it only being recommended that they be not used below 10° C.

Chemical Engineering.

Producer Gas.—In a paper read before Section G of the British Association at Dublin by J. Emerson Dowson some interesting comparisons are made between suction and pressure gas, as he classifies the two kinds, depending on the method of introducing the air to the producer. The calorific power of pressure gas made with a jet of superheated steam is usually higher than that of suction gas. In the former the percentages of hydrogen and carbon monoxide are higher, while the percentage of nitrogen is lower. If the gas is to be used for heating purposes in small burners or in blowpipes it is better to use pressure gas than suction gas. Suction gas contains a smaller percentage of combustible than pressure gas, requires less air for combustion, but as the loss from fluid friction is greater an engine using suction gas develops less maximum power, this power loss becoming serious in engines above 200 hp. Fuel consumption in a pressure plant with independent boiler is higher than in a suction plant. The suction plant costs less and occupies less space, but the gas made is not so strong as with a pressure plant. For small plants anthracite or gas coke should

be used for fuel, the labor and plant necessary for removing the tar in small installations more than offsetting the cost of the cheaper bituminous coal. For large plants this latter fuel is always used.

Peat.—Before this same section was also read a paper on "The utilization of peat for making gas or charcoal with recovery of by-products," by H. Riall Sankey. This subject has received considerable importance in Ireland from the proposed bill asking permission to build a power station and to supply power at Robertson, 25 miles from Dublin, the fuel to be used being peat. By using a mechanical excavating bucket it is estimated that the peat can be cut and passed through a Dornberg press for 75 cents a ton. The Ekenberg process of drying peat may find application here. When peat containing over 90 per cent water is exposed to a temperature of over 150° C. the slimy hydro-cellulose is decomposed and the peat is partly carbonized. In this condition the peat can be squeezed practically dry. No by-products are lost. Dr. Ekenberg gives as the cost of the operation 75 cents per ton of dry peat produced. Gas producers suitable for the production of gas from lignite, of which there are a number on the market, are suitable for peat burning. Their capacity is somewhat less than when running on lignite. An average analysis of dry gas is given as CO, 12 per cent; CO₂, 18; CH₄, 2.8; H₂, 24; N, 43.2. The only by-product so far recovered in a gas plant using peat as fuel is sulphate of ammonia, the recovery being reported as worth \$1 per ton of peat burned, the original cost of the peat being only 75 cents. This output is rather a variable factor, depending on the proportion of nitrogen in the peat. An experimentally proven power output of 1000 boiler horse-power hours per ton of peat burned in the producer would fix the cost at about 0.1 cent per horse-power hour, not including profit from recovery of by-products. (The subject of utilization of peat was fully discussed in our Vol. V, pp. 392 and 405).

Of considerable interest are some remarks made in the discussion by Mr. Crossley, of the well-known firm of gas engine makers, who, according to the *London Electrician* of Sept. 11, thought that at last there was a prospect of some success being achieved. He supported Capt. Sankey's statement that peat was economical, even if it contained as much as 60 per cent of moisture; his own company had proved this by experiment. With regard to the application of peat fuel to the production of electrical energy, he maintained that, owing to the value of by-products, the fuel costs would be reduced to zero. He gave figures relating to a plant for the carbonization of 10 tons of dry peat per hour; the capital cost was put at \$250,000, and it was estimated that each ton of peat would produce 140 tons, or even 170 tons, of ammonium sulphate. Putting the amount of nitrogen in dry peat as 2.2 per cent, and allowing a suitable amount for depreciation of plant, etc., the profit worked out at \$120,000 per annum. On this basis the cost of production per ton of sulphate was about \$27.50, while the selling price was \$57.50. These figures make no allowance for the sale of gas.

Iron and Steel.

Corrosion.—The corrosion of iron is still the center of numerous investigations, W. A. Tilden presenting a new series of experiments in the *Journal of the Chemical Society* for July. Soft Swedish iron was used in all the experiments in the form of rods, $\frac{1}{4}$ in. in diameter, turned bright and polished with emery. The Moody experiments were repeated with three rods, one-half of one bright, the other half file-roughed; the second was heated in hydrogen to reduce the scale and then red hot in a vacuum; the third was exposed to a 1 per cent solution of chromic acid; all were placed in the same piece of tubing. Air which had bubbled through and stood in contact with KOH solution was passed over the iron for five days, and then water was distilled onto it. Samples 1 and 2 rusted inside 20 minutes, 3 not at all. After six months' standing 3 showed only a small patch of rust, and that was noted a short time after the experiment was started. Next the iron was subjected to a current of

most carefully purified oxygen for three days, and then water was distilled onto it. Rusting took place in 10 minutes. On repeating the experiments with greater precautions for excluding CO_2 , the iron rusted in 20 minutes. No action was noted with water on iron treated with chromic acid, provided the water contained no other substances. Walker's experiments on the solution of iron in water were repeated and his conclusions confirmed. Iron goes into solution as $\text{Fe}(\text{OH})_2$; in air this becomes FeCO_3 . Analysis of iron rust 250 years old showed 9.2 per cent ferrous iron; total iron, 62.05 per cent. The following facts were considered to have been established: Metallic iron water and oxygen are alone sufficient for the production of rust; CO_2 is not necessary, but its presence assists in the production of rust; iron is attacked by pure water in the absence of O and CO_2 , the product being $\text{Fe}(\text{OH})_2$; iron rust always contains FeO . The process of rusting is due to electrolytic action, the products being $\text{Fe}(\text{OH})_2$ or FeCO_3 and may be explained by the presence in the iron of various compounds which form surfaces of different potential in the electrolyte of water or aqueous carbonic acid.

Along a directly opposite line from the preceding is a paper on "passivity in acid solution," by J. Alvares, appearing in *Zeitschrift für Elektrochemie*, Sept. 11. This may be mentioned here, although not relating to iron. A nickel anode was dipped into a 5-n sulphuric acid solution, the cathode of the cell being formed of a heavy copper spiral dipping into a copper sulphate solution in a clay cell. The voltage across the terminals of the cell for a given applied current was:

Current.	Voltage.
0.05	0.15
0.055	0.17
0.060	0.185
0.065	0.20
0.070	0.22
0.080	0.24
0.085	1.75

Thus it appears that a certain current density is necessary to make the nickel anode passive; above 1.5 volts tension across the terminals of the cell oxygen was evolved from the anode. Below that tension solution took place according to Faraday's law, while above practically no solution took place. The addition of a halogen salt lowered the required current density, though the anomalous result was arrived at that increasing additions of halogen salt caused a rise in the necessary current density for making the anode passive. The cause of the phenomenon of passivity is believed to be due to the formation of an insoluble hydroxide or basic sulphate precipitate on the surface of the nickel. The author proposes this explanation of the formation of this coat: It must be assumed that the transport of negative electricity to the anode is due to the precipitation of negative anions like oxygen. The charged oxygen combines with the metal of the anode and the oxide formed dissolves in the solution.

If the delivery of oxygen to the anode is more rapid than the oxide formed can dissolve, then the electrode becomes covered with the insoluble coat and becomes passive. It is only when the depolarization of the anions by metal takes place as fast or faster than the current delivers them that the electrode dissolves according to Faraday's law.

Blast Furnace.—The lighting of a blast furnace has always been more or less of a problem to the furnace men, and Mr. C. S. Proudfoot will no doubt incur the thanks of a large number of them for the convenient little electric apparatus that he has devised for this purpose. It is described in *Iron Age*, Sept. 17. A short section of electric conduit is fitted with an iron point. One-half of it is cut away just behind the point, and in the trough thus formed is placed two pieces of electric light carbon insulated from each other. Their ends are brought within $\frac{1}{4}$ in. of each other, and this gap is bridged with a short piece of 3 amp fuse wire. The carbons are connected to leads, which in turn through suitable resistance are connected with

the arc circuit of the plant. A mass of excelsior, saturated with alcohol, is tied over the gap between the carbons. In use the igniter so prepared is pushed in through a tuyere, connection made with the lighting circuit, the fuse blows, springs an arc between the ends of the carbon, and so lights the excelsior. In practice four are used at one time.

Some light is at last thrown on the cause of a number of mysterious blast furnace explosions by W. van Vloten in an article in the July 15 number of *Stahl u. Eisen*. The cause of these explosions are believed to be generally due to the sudden and intimate mixture of a mass of fine ore and fine coke at a red heat. In most cases the explosions follow by several seconds a slip in the furnace. It is impossible to conceive of their being produced by a mixture of air and gas, because it is not possible to introduce air at the point where they have usually shown their greatest destructive action. In proof of this theory the author took a large diameter tube, inside of which was placed two smaller tubes filled with ore, the space surrounding these tubes being filled with fine coke. On heating the free end red hot and suddenly inverting the whole so that the fine coke and the ore were intimately mixed at a red heat, an explosion took place, which recorded a pressure of 4 At. on a pressure gauge attached to the large tube. No explanations are offered as to why explosions are more frequent when the furnace is charged too frequently in the center.

Foundry Cupola.—In a paper on "foundry cupola construction," read before the New England Foundrymen's Association at Boston, Sept. 9 (reprinted in *Iron Age*, Sept. 24), Mr. T. D. West divides the demands made on the cupola in special and general practice into 14 classes, each requiring a special cupola. For continuous running the cupola should have the main tuyeres 3 to 4 ft. above the bottom plate and the slag hole 12 to 18 in. below the lower row of tuyeres; the height should be 16 to 20 ft., the inside diameter 60 in. and the walls straight. For intermittent running all parts of the cupola should be so designed as to permit of being closed air tight. For melting fine and dirty scrap, steel scrap, tin scrap and sheet iron mixed with pig iron the cupola should be provided with two rows of tuyeres, the lower row 24 to 36 in. above the bottom plate and 36 to 50 in. in diameter; if above 60 in. in diameter this cupola should be provided with center blast. It should not be over 16 ft. high. For the rapid melting of large heats the tuyeres should be high, a slag hole 8 to 12 in. below the tuyere level should be provided, and a pressure of 8 to 12 oz. for the blast passing in through large tuyeres is essential. The cupola for this purpose should be boshed if over 50 in. in diameter. Where rapidity of melting is the only desideratum the tuyere level should be low, no slag hole is necessary, and the walls should be boshed for cupolas over 40 in. in diameter; if over 60 in. a center blast is necessary. The question of fuel economy is more concerned with the handling of the cupola than with its general design. The highest economy is attained by working to the fullest capacity of the cupola, to attain which the center blast should be used for furnaces over 60 in. in diameter, with the lowest row of tuyeres 18 to 24 in. above the bottom plate. For continuous tapping a larger tuyere area must be supplied than for intermittent tapping. When coal is used for fuel smaller and lower tuyeres are required than for coke. A second row of tuyeres means a new smelting zone, with consequent wear and tear on the lining. A tap hole requires the use of limestone as flux. A center blast allows of the use of lower blast pressures.

One of the greatest disadvantages of the foundry cupola is the fact that as ordinarily driven it cannot be used for melting low carbon irons. As the engineer is often looking for a cheap material intermediate between cast iron and low carbon cast steel, he is forced to use a substitute. Such a product may be made in the Siemens-Martin or the reverberatory furnace, but the cost is excessive. Before the Köln-Aachner Section of German Iron Founders, K. Schiel read a paper on the use of oil for firing cupolas. The paper is printed in detail in *Stahl und Eisen*, Aug. 19. The cost of oil firing is but slightly higher

than the use of high-grade coke. Analyses of mixtures after melting with oil usually show a considerable loss of both carbon and sulphur in the melting. A large number of burners suitable for this purpose are described.

Gold.

Amalgamation.—The September number of the *Western Chemist and Metallurgist* contains an article by J. H. Haynes on "The proper way to clean and dress plates during amalgamation." From experiments on the collecting of gold on fabrics it is well known that the longer the nap of the goods the better the recovery. The same is true of the nap which forms on a plate in use, and under no circumstances should the nap be disturbed unless it hardens excessively or a crust forms on the surface. To offset the smoothness of the plate after scraping, the brush should be worked across the face of the plate, forming a series of small ripples in the same. The use of cyanide in the stamp mortar softens the amalgam excessively and makes it harder to catch on the plates. Usually the use of cyanide can be detected on sight because the amalgam is found adhering over the whole length of the plates. Cyanide dissolves gold out of amalgam very readily.

Miscellaneous.

Enamels.—The high price of tin oxide has led to the search for substitutes in the enameling industry. A paper on such substitutes by Ph. Eyer is to be found in *Stahl und Eisen* for July 29. Most enamels contain from 20 to 40 per cent tin oxide. As much as 12 per cent of the tin content may be replaced by cryolite. Where the vessels are not to be used for containing food, antimony and arsenic oxides may be used to replace the more expensive material. Bone ash has been tried, but the stronger acids in the enamel decompose it, with consequent chipping and formation of bubbles. Titanic acid makes too brittle an enamel and zirconium oxide is too expensive. An enamel composed of high cryolite and alumina content and only 5 per cent tin oxide possesses great covering power if not too finely ground.

Radium.—Before the spring meeting of the Deutsche Bunsen Gesellschaft, May 30, 1908, Dr. Heinrich Paweck delivered an address on the extraction of radium from pitchblende. The address, which contains a full sketch of the procedure, is printed in *Zeitschrift für Elektrochemie*, Sept. 11, 1908.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Graphite.—E. Cornelius (900,486, October 6, 1908), endeavors to make artificial graphite production a continuous process and also tries to avoid special carbon resistors, which in present practice are required to start the operation. For this purpose he uses the furnace shown in vertical and horizontal section in Fig. 1. Its operating chamber is ring-shaped, so that charging, heating and discharging of the substance can be effected simultaneously and continuously, and the heating place can be changed successively along the operating chamber. The bottom part 3 is of carbon and forms one of the electrodes. The other electrode 4 is mounted from above in the operating chamber of the furnace and has a vertical position. It is fixed in a turnable arm 5. The charge is introduced, for example, at *b*, and the product is discharged at *a*, the material being charged into one portion of the furnace, while a previous charge is being treated in another portion of the furnace. In the upper diagram, for instance, the left-hand portion of the furnace is in operation, while the right-hand portion is ready to receive a fresh charge. The electric current between the electrodes is kept constant by turning the electrode 4 in the direction of the arrow, when necessary, so that it is mounted into less conducting carbon powder, i. e., carbon powder of a lower temperature, provided that the furnace is in full action.

Mercury Still.—C. T. Knipp (891,264 and 891,265, June 23, 1908) employs an electric still for purifying mercury and other suitable metals by vaporizing them *in vacuo* and condensing the

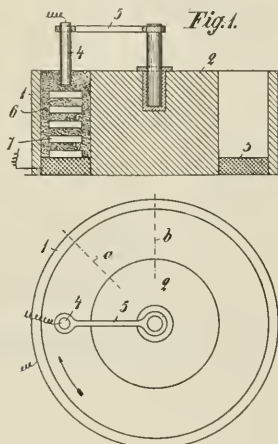


FIG. 1.—GRAPHITE FURNACE.

vapor in a separate condenser. The liquid mercury is separated into two portions which are used as the electrodes of an arc while the air is exhausted. The mercury vapor is condensed in the condensing chamber and leaves it through a capillary tube. This air-pump action maintains the vacuum in the still.

Various Designs.—R. McKnight (900,192, Oct. 6, 1908), patents a revolving cylinder through which the ore travels in one direction and comes in contact with hot air and gases passing in the opposite direction (as is the case in many roasting furnaces). The electrical feature of the design is that the hot air is produced at one end of the cylinder by means of arcs between carbon electrodes.

J. H. Reid (900,207, Oct. 6, 1908), tries to solve the problems of the treatment of complex ores by an arc furnace which, on paper, is very simple. The ore is subjected to the action of a series of arcs, each of which is intended to be regulated so as to produce such a temperature as to volatilize ore metal.

Electrolytic Furnaces.

Magnesium.—G. O. Seward and F. Von Kugelgen, who have carried out in recent years so many interesting joint researches with fused electrolytes, patent (900,961, Oct. 13, 1908; assigned to Virginia Laboratory Company) a new process for the production of magnesium by electrolysis of fused magnesium fluoride mixed with an alkali chloride, like calcium chloride. MgF_2 and $CaCl_2$ are mixed and melted and heated until all the water is driven out. The addition of a small percentage of an alkali fluoride as a flux assists in this operation. The resulting molten mixture is electrolyzed, and pure magnesium is obtained at the cathode and chlorine at the anode, the $CaCl_2$ having been changed to the fluoride. When the electrolyte becomes too poor in magnesium it is worked over as follows: It is mixed with fused hydrated $MgCl_2$ and heated until all water is driven out. The magnesium chloride and calcium fluoride ($MgCl_2 + CaF_2$) change to magnesium fluoride and calcium chloride ($MgF_2 + CaCl_2$).

Barium and barium alloys.—The same inventors (900,962, Oct. 13, 1908) produce barium or barium alloys by electrolysis of barium chloride mixed with fluoride. A mixture of 90 per cent barium chloride and 10 per cent barium fluoride is successful. A special feature of the process is the use of a high cathodic current density, or, what is the same, the use of a small-sized cathode. If metallic barium is to be produced, an

iron cathode is used. For the production of alloys of barium, a cathode is made of the metal with which the barium is to be alloyed.

Aluminium Alloys.—H. S. Blackmore (886,757, May 5, 1908) takes oxides of lithium and calcium in the proportion of about four of the former to one of the latter and fuses the same, for instance, by electric current. He then adds "to the bath an aluminate of the metal an alloy of which, with aluminium, is desired, which readily dissolves therein, and simultaneously subjects such dissolved aluminate, which has been

mon salt circulation is necessary, we have just the opposite requirement in the case of production of **chlorine and caustic** by electrolysis from the same solution. Here it is of prime importance to keep the anodic and cathodic products separate. We have for this purpose the different types of diaphragm cell, mercury cathode cell, and gravity cell. A recent process of H. S. Blackmore (884,124, April 7, 1908) employs a combination of diaphragm and gravity cell. The cell is shown in Fig. 2, showing a horizontal and a vertical section. The whole tank is divided by two cross-partitions B and B^1 into three compart-

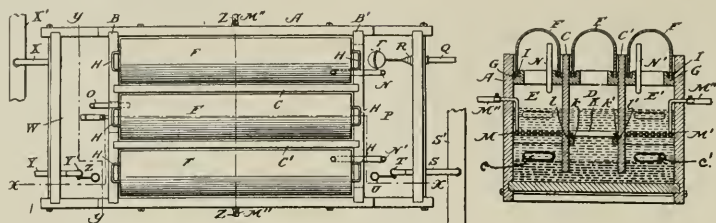


FIG. 2.—DIAPHRAGM CELL.

liquefied below its normal melting point by the action of the associated solvent substances," to the action of an electric current, whereby an aluminium alloy is set free. It is essential in this process that such oxides are used which have a higher affinity for oxygen than the aluminium alloy, for instance, lithium, calcium and magnesium. A carbon-lined iron box, which forms the cathode, is filled with the mixture of lithium and calcium oxides, and two sets of carbon electrodes are introduced through the roof; one for the heating current and the other forming the anodes for the electrolyzing current. By closing the circuit for the heating current, the calcium and lithium oxide mixture is fused. The circuit for the electrolyzing current is then also closed. When, for instance, copper aluminate is then added, it becomes immediately liquefied and a copper-aluminium alloy is set free at the cathode.

Electrolytic Processes.

Electrolytic Copper.—To produce an absolutely homogeneous electrolytic copper deposit, deposition on a revolving cylindrical cathode, with a simultaneous polishing of the deposit by special devices, has already been successfully employed by various inventors. The special feature of a recent patent of M. A. Jullien and E. L. Dessolle (897,291, Sept. 1, 1908) is the construction of the polishing tool which makes a reciprocating movement, moving longitudinally on the cylinder in such a manner that the polisher describes on the copper deposit not simply a screw thread, but a sinusoidal curve surrounding the spires of the screw thread. The sinusoidal curves interengage in such a manner that no point of the surface escapes the action of the polisher. The polisher is, of course, applied to the surface with a suitable pressure.

Sodium Chloride Electrolysis.—For chlorate production circulation of the electrolyte is important. G. C. Landis (897,633, Sept. 1, 1908) employs a construction in which both the anode and the cathode are flat graphite plates, spaced apart by a flat frame of rubber in the form of narrow strips placed between the plates near their edges and forming with them a hollow, thin container or cell. Projections extend alternately from the upper and lower sides of this frame; they act as baffle plates and force the electrolyte, after it has entered the cell, to flow in a circuitous path, alternately upward and downward between the baffle plates to the exit. The direction of flow of the electrolyte is always perpendicular to the direction of the electric current.

While for the production of chlorate by electrolysis of com-

ments, and the middle compartment is again divided by two longitudinal partitions C and C^1 (which do not reach to the bottom) into three compartments E, D, E^1 , of which D is anode compartment and E and E^1 are the cathode compartments. K is the carbon anode, while M and M^1 are copper grids forming the cathodes. O is the outlet pipe for chlorine, N and N^1 for hydrogen. Communicating with the cathode compartments E and E^1 through the openings c and c^1 in the wall B^1 is the supply and discharge compartment P . In a similar way the supply and discharge compartment W at the other end of the tank is in communication with the anode compartment D . The charge and supply is regulated by means of float valves. A heavy solution of caustic soda (40° B.) is placed in the bottom, so that its upper level is just below the slotted openings c and c^1 . On this caustic soda solution rests "a film of powdered cannel coal, carbonized silicon or silicon carbide, the gravity of which has been reduced by heating with carbonaceous material. The heavy caustic potash solution in the bottom forms a liquid diaphragm and seal between the anode and cathode compartments. A solution of potassium chloride of about 24° B., is then supplied to the anode compartment and a solution of caustic potash of like density supplied to the cathode compartment until the two solutions shall stand in the various compartments at a uniform level resting upon the lower heavy solution of caustic potash, which acts as a liquid diaphragm during electrolytic action." The fine dust of powdered cannel coal or carbonized silicon is so prepared that it will sink in the lighter solutions in the various compartments and remain resting upon the heavy caustic potash solution or diaphragm. This film of substance resting upon the heavy liquid caustic potash diaphragm forms a sort of skin or elastic medium whereby the diffusion of the separate liquids into each other is prevented or largely obviated." The patent has not less than 81 claims.

Chromium Deposits.—A few years ago, the work of Carveth in this country and Le Blanc in Germany attracted attention to the electrolytic production of chromium deposits, as plating with chromium should offer decided advantages for certain purposes. F. Salzer (900,597, Oct. 6, 1908) produces in the following way "a very coherent and firm deposit of any thickness, much harder than steel, very flexible and of fine color." He uses a solution of a mixture of chromium trioxide CrO_3 and chromic oxide Cr_2O_3 in the proportion 4 to 3 or 1 to 1, with a small amount of acid. A cathodic current density of 2 to 5 amp per square decimeter with 3 to 6 volts at the terminals of

the tank is used at ordinary temperatures. The composition of the bath may be held constant by using insoluble anodes, which facilitate the oxidation of about as much chromic oxide to chromium trioxide, as chromium trioxide is reduced at the cathode. Anodes of fused ferroferrous oxide, Fe_3O_4 , are recommended.

Silver Reflector.—Incandescent electric lamp globes are often silver plated to a certain extent to produce a reflector for the light and it has been the practice to coat the silver film with varnish. This has the disadvantage that the heat of the lamp causes the varnish to curl up, pulling the silver from the glass. J. A. Yunk (900,340, Oct. 6, 1908) coats the silver film with the protective layer of copper by electrodeposition. For this purpose he uses a special copper anode so shaped as to conform to the outside surface of the lamp bulb in order to produce a uniform deposit.

Seamless Plated Wire.—Ingots suitable for reduction into seamless gold or silver plated wire for jewelers' use are made by electroplating a layer of gold and silver on a core of common metal according to a process of F. Cutter (899,827, Sept. 29, 1908). Such plated rods are then subjected to heating and pressure by means of shot. For this purpose the coated rod is placed in an ordinary rattling barrel containing shot and the drum is rotated. By mixing a liquid soap with the shot a more polished surface is secured. If a thin plating of metal is all that is desired, the ingot is then ready for reduction to seamless wire. If a heavier plating is demanded, the above process of plating and beating is repeated.

Plating the Inside of a Tube.—G. A. Lutz (899,226, Sept. 22, 1908) plates the inside and outside of tubes by immersing them in a tank containing anodes around the tubes and also anode rods inside within the tubes. Instead of such a solid metallic anode rod a perforated insulating tube may be used containing pieces of the anode metal, which are, of course, connected to the positive pole of the electric circuit.

Plating Small Articles in Mass.—J. T. Daniels (901,280, Oct. 13, 1908) uses a tank with a rotatable container for the articles to be plated. The anodes are placed in the tank outside of the container. The container is placed in an inclined position (neither horizontal nor vertical), and is of truncated cone shape. In the center of its rather extended bottom the cathode is provided. The walls of the container are, of course, perforated. When the container is rotated and the circuit is closed, the small articles are pressed not only by gravity, but by centrifugal force against the cathode and against each other to intensify the electrical contact. At the same time the electrolyte is thoroughly agitated within the container so as to bring always fresh metal solution to the surfaces to be plated.

Plating Metal Sheets.—H. L. Hollis (900,169, Oct. 6, 1908) patents mechanical details of an apparatus for electroplating metal sheets. A number of vertical rotatable rollers are so disposed as to convey the sheets through the plating bath. The rollers are so spaced that one set of rollers engages a sheet before the preceding set releases it, in order to secure a continuous movement of the sheet through the bath.

Lead Peroxide Electrodes.—An indestructible anode is an important requirement for many electrolytic processes. Platinum is excellent for many purposes, though very expensive. Artificial graphite has been found to be an ideal material for many processes like electrolysis of chlorides, but it is not recommended for the electrolysis of sulphates. Lead peroxide plates have also been used in various cases. P. Ferchland and J. Nussbaum (900,502, Oct. 6, 1908) make such lead peroxide electrodes by using metallic rods or plates (which form the core of the final electrode) as anodes in a strong solution of nitrate of lead, containing, say, 25 per cent of salt. Colloidal substances, such as gum arabic, etc., may be added in order to make the deposit more smooth and glossy. The anodes are rotated. Cathodes of copper or other metal are used. The anode current density is 6 amp per square decimeter.

Purifying Liquids.—There is no lack of patents for purify-

ing liquids by electrolysis. Most of them employ electrodes forming a hydroxide which combines with and coagulates the organic matter in the water. This is also the case in the patent of J. T. Harris (900,926, Oct. 13, 1908). He uses iron anodes for this purpose, but he also employs a magnetic field acting upon the iron anodes and the liquid in contact with them. He further agitates the water by injecting upward through it bubbles of filtered air, which may be partially ozonized. He ascribes the formation of the voluminous, colloidal hydroxide to "the combined action of the electric current, magnetic field and injected air."

Diaphragm Cell.—A. S. Gray (884,015, April 7, 1908) builds a diaphragm cell with horizontal anodes and cathodes separated by a canvas diaphragm. The cathodes are at the top. The cell is placed in an inclined position to permit the hydrogen gas evolved at the cathode to escape. To facilitate the further escape of the gas, the cathode chamber is provided with numerous vent openings, which connect with tubes leading to the outside.

Solvent.—E. C. Broadwell (884,705, April 14, 1908) patents a solution which is not only claimed to be a good solvent for metals, but also a suitable electrolyte for later depositing the metals without evolution by hydrogen. The solvent consists of the sulfonic acids of the carbocyclic hydrocarbons, or of the carbocyclic oxy-compounds, such as the phenols, aldehydes and carboxylic acids.

Batteries.

Storage Batteries.—To give greater mechanical strength to the active masses of storage batteries, M. C. Thieiller and M. J. Denard (900,898, Oct. 13, 1908) mix the lead oxides used for preparation with "gelatine gelatinized in aqueous bichromate of potash, and asbestos fiber emulsified in sulphuric acid and silicate of soda." Detailed instructions on the procedure are given.

W. Morrison (900,571, Oct. 6, 1908) uses a zinc battery with horizontal electrodes, separated from each other by an insulating diaphragm resting on the lower electrode and supporting the upper one. The lower electrode consists of a number of superimposed screens intended to receive the zinc. Since all the zinc is intended to be at the bottom of the cell and since the cell itself has metal walls, it is necessary to line the inside with an insulating band. This insulating lining rests on the edges of the lower zinc electrode.

H. C. Hubbell (897,833, Sept. 1, 1908) makes small alkaline batteries of the general Edison-Jungner type for use with transportable lamps. The active material of the positive plate is formed of 60 per cent nickel hydrate $\text{Ni}(\text{OH})_2$ and 40 per cent silver oxide Ag_2O , which are reduced to an impalpable powder, mixed and pressed into the form of a tablet. The negative plate is a similar pressed tablet of mixed cadmium oxide and an impalpable powder of metallic nickel. The electrolyte is sodium or potassium hydroxide.

Primary Batteries.—W. A. F. Bleeck (899,823, Sept. 29, 1908) patents the construction of a double-fluid primary cell with a zinc electrode in an "exciting" solution of one part of sodium hydroxide in two parts of water. The other electrode is made of carbon and is placed in the depolarizer. The exciter is separated from the depolarizer by a porous partition. The depolarizer is made by dissolving 5 oz. of chromic acid in 10 oz. of a 3 per cent solution of hydrogen peroxide in water and by adding 5 oz. of hydrochloric acid.

I. Kitee (901,012, Oct. 13, 1908) tries to avoid the depolarization of the carbon element of a primary battery by the catalytic action of platinum black. He states that it is necessary to supply oxygen to keep up the catalytic action. For this purpose he makes use, for instance, of a carbon disk covered with platinum black and rotates it. Parts of the surface are thereby brought out of the electrolyte and in contact with air, which provides new oxygen.

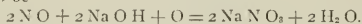
Mechanical Details.—A patent of J. Marx (897,472, Sept.

1, 1908) refers to details of construction of a jar for storage batteries. It has an inner shell of acid-resisting hard rubber and an outside protective casing of metal.

11. J. Brewer (900,476, Oct. 6, 1908) patents details of construction of a cover for primary batteries. The cover is provided with a radial slot for receiving the carbon electrode.

Electric Discharges Through Gases.

Fixation of Atmospheric Nitrogen.—By means of arc and spark discharges through atmospheric air it is possible to force part of the oxygen and nitrogen of the air into a chemical combination. But the further treatment of the resulting gas mixture still offers difficulties. C. N. Rüber (899,705, Sept. 29, 1908) endeavors to produce pure nitrites free from nitrates. For this purpose the gases from the electric apparatus are at once directed into absorption apparatus containing alkalis or alkaline earths, and before the oxidation of the nitric oxide NO to nitrogen dioxide NO₂ takes place. The gases may be advantageously cooled. The reaction which takes place is stated to be



Ozone.—J. R. Craig, Jr. (894,818, Aug. 4, 1908), patents the construction of electrodes for the production of ozone by silent high-tension discharges. His electrode unit consists essentially of a strip of micanite, on each side edge of which, near the top and near the bottom, are fastened little metal projections to the micanite. On each side a metal spring is stretched between the two projections. The two opposite metal springs are electrically connected to the two poles of the high-tension circuit. "The springs, when charging and discharging the dielectric medium, will vibrate synchronously with the interruptions or cycles of the high-tension current." Modifications of the construction and the methods of assembling a number of such electrode-units into a compound electrode are also described.

To prevent the destruction of the electrodes in an ozonizer, J. R. Quain (898,506, Sept. 15, 1908) proposes to use both of them in vacuo. Each electrode is contained in a vacuum tube and the vacuum tubes are placed in a parallel position, the air to be ozonized passing along the exterior of the tubes in the direction of their lengths.

RECENT METALLURGICAL PATENTS

Iron and Steel.

Blast Furnace.—To prevent any danger of clogging, sticking or hanging of the contents or burden of a blast furnace with the result of a slip, J. H. Meissner (900,291, Oct. 6) proposes to make the bosh independent of the hearth. A special structure is provided to support the bosh, and the latter can be made to rotate. By giving this section a slow, steady movement at desired intervals, the feed of the ore past this section into the hearth below is insured. Naturally this means a somewhat complicated construction and it is necessary to keep the joints between the movable and the adjoining stationary sections cool, so as to prevent an outflow of fluid from the interior of the furnace. For this purpose artificial cooling of the joints by means of water boxes is employed and air pressure is applied to the exterior of the joints. The walls of the bosh are kept cool by moist layers of sand, held in position by means of screens and continually moistened by a flow of water from perforated pipes. This arrangement is stated to be much cheaper than the bronze plating now employed. It is said that in operation it is ordinarily necessary to give the bosh a slow back and forward movement only at intervals.

Basic Open-hearth Steel.—Heretofore it has been considered impracticable to melt a charge of pure wrought iron in an open-hearth furnace without the addition of pig iron. A process of J. W. Maxwell (900,564, Oct. 6) is said to make this possible. It is said to yield steel of any carbon content de-

sired, from very soft to extremely hard, from iron and steel scrap with the use of pig iron. The process is as follows: Pig iron in small quantities, and preferably a neutral pig iron, that is, a pig iron low in silicon and phosphorus, together with limestone, lime or other suitable material containing calcium, are first charged into an ordinary open-hearth furnace. A quantity of charcoal, coal or coke is then quickly spread over the charge of pig iron and limestone, the quantity being such as to give the required or a greater percentage of carbon than is necessary to secure the required percentage of carbon in the finished steel. This carbonaceous material is then quickly covered by the scrap iron or steel to be used, so as to protect it from exposure to the free oxygen in the flame in the furnace, as the object in using a carbonaceous material in this way is not to secure heat for melting the charge, but solely to add carbon to the scrap iron or steel used. When thus treated, a charge of scrap iron or steel absorbs or takes up enough carbon during the melting period to not only lower the melting point enough so that they are readily melted at the ordinary temperature maintained in an open-hearth furnace, but also to produce steel of a very high carbon from very pure materials if so desired. After the charge has been melted down as described, the refining of the bath is then proceeded with in the ordinary manner, and after the required refining has been accomplished and the carbon reduced to the desired percentage, the bath is tapped out of the furnace, the usual final addition of ferro-manganese, ferro-silicon, aluminium, etc., being added either in the furnace or in the ladle.

Nickel, etc., from Matte.

Removal of Arsenic, Recovery of Silver, Nickel, Cobalt, etc.—Three recent patents of A. J. Wadhams and R. C. Stanley (900,452, 900,453, 900,454, all of Oct. 6, 1908, and all assigned to the International Nickel Company) refer to the complex problem of separating the copper, nickel, cobalt, silver and arsenic, contained together in speiss or other arsenical matte.

Removal of Arsenic forms the first part of the process. The speiss is roasted in a calcining furnace at a cherry-red heat until the arsenical fumes cease to come off. The calcined material is then ground with coal or charcoal and roasted in a reducing atmosphere, which reduces the arsenical compounds to arsenides. This is followed by an oxidizing roast which liberates arsenic fumes. The alternate reduction and oxidation are repeated until the fumes of arsenic cease to be liberated. Material which originally contained 35 per cent arsenic, 16 nickel, 25 cobalt and 10 iron, will contain at this stage about 4 per cent of arsenic. The further treatment may be carried on by either of the following two methods, A or B.

Treatment A: The material is ground to 80 mesh and treated with sulphuric acid of 35° B at boiling temperature, dissolving a large proportion of the silver and some of the copper, nickel and cobalt. By passing the solution over copper shot or copper sheets, the silver is separated by cementing and is then washed, dried and smelted. The remaining solution is neutralized with caustic soda and evaporated to 40° B., whereby the nickel and cobalt are precipitated as crystalline sulphates. The crystals are calcined and changed into oxides, which are dissolved in hydrochloric acid. The iron is precipitated with lime, leaving a solution of chlorides of copper, nickel and cobalt, and a small proportion of silver chloride. The residual silver is precipitated with hydrogen sulphide, and the nickel and cobalt are separated by known methods.

Treatment B, instead of A, is more elaborate and proceeds as follows: The material, resulting from the previous treatment, is mixed with 1 part of nitrate of soda and 2 parts of soda ash to each part of arsenic contained in the material, and the mixture is calcined at a cherry-red heat, until all the arsenic is converted into arsenate of soda. The material is withdrawn from the furnace and washed in a wash tank until the arsenate of soda is dissolved. The solution is concentrated by evaporation and the arsenate of soda crystals form a valuable by-

product. In this way the content of the arsenic in the undissolved material can be reduced to 0.5 per cent.

The residual material consists of oxides of copper, nickel, cobalt, iron, silicon, aluminium and calcium and of metallic silver. It is treated with concentrated hydrochloric acid in a revolving cylinder at a pressure of about 60 lb. to 80 lb. and a temperature of 135° Fahr. for six to eight hours. The hydrochloric acid dissolves the chlorides of the several metals except most of the silver. The undissolved silver and silver chloride are allowed to settle for subsequent removal and smelting. The solution is drawn off and by means of caustic lime the iron is precipitated as a hydrate and the last of arsenic is removed. The solution, freed from iron and still acid, is treated for the removal of copper and silver by passing sulphuretted hydrogen through it, which precipitates the copper and silver as sulphides, which are washed, collected and smelted. The remaining solution contains chlorides of nickel and cobalt, which are separated by known methods.

Zinc.

Low-Grade Sulphide Ores.—A patent of F. P. Dewey (900,088, Oct. 6, 1908) relates to the conversion of zinc oxide into sulphite of zinc and particularly to the treatment of the mixture of galena, pyrite and blende, carrying a small amount of silver, which is commonly spoken of as "low-grade sulphide ore." Various processes have been proposed, in which the ore is roasted and then treated with the sulphurous acid given off in roasting, in order to convert the zinc into sulphite, which is dissolved in water, and separated from the residue containing the lead, iron and silver. For such schemes it is important to bring the zinc of the roasted ore into solution in a minimum quantity of water, and this the present inventor tries to secure by the use of a very large amount of sulphurous acid applied in a particular manner. The fundamental fact is that the amount of oxide of zinc held in solution by sulphurous acid water depends upon the amount of sulphurous acid present in excess of the quantity required to convert the zinc oxide into sulphite; and that the ores under consideration do not yield sufficient sulphurous acid on being roasted to get such concentrated solutions. It is, therefore, necessary to have an excess of sulphurous acid, and this the inventor obtains by the subsequent manipulation of the solution of sulphite of zinc and the decomposition of the zinc sulphide itself, so that he uses his sulphurous acid over and over again, and thus has an abundant supply of sulphurous acid and a continuous process.

His concentrated solutions of sulphite of zinc in sulphurous acid water deposit crystals of zinc sulphite, on losing their excess of free sulphuric acid. This is accomplished by heating or by applying a vacuum, or by both means. The evolved sulphurous acid is passed into a new charge of roasted ore. The solution deprived of its excess of sulphurous acid gas will still contain some zinc, and, in order not to waste this, the liquid is cooled and then recharged with sulphurous acid and used in treating a fresh lot of ore so as to saturate it again with zinc. Further, it is a fact that in dissolving zinc oxide in sulphurous acid water, it is easier to keep the zinc dissolved in a small volume of water than it is to dissolve already formed zinc sulphite in the same amount of water. During the dissolving operation any separation of zinc sulphite is, therefore, avoided. This is secured by always having an excess of free sulphurous acid present in the solution. The roasted ore is added in small portions at a time to the sulphurous acid water and fresh sulphurous acid gas is supplied to the solution while the zinc is being dissolved. The zinc sulphite crystals finally obtained, when heated for a short time to 1000° C., are completely decomposed and yield a very pure zinc oxide, practically free from sulphur (less than 0.01 per cent).

Zinc Alloy.—According to W. J. Leddell (901,014, Oct. 13, 1908) an alloy containing 90 per cent zinc, 5 aluminium and 5 copper, has a relatively low factor of shrinkage, and a relatively high resistance to distortion from impact or pressure. It

has a dense, homogeneous structure, substantially free from segregated masses of crystallized zinc. It is said to be particularly adapted for the production of light castings in iron molds, without the use of expandable cores, and to be especially suitable for various electrical and mechanical work, since a smooth finished casting may be obtained without machining.

Electric Steel Furnaces in Europe.

Stahl und Eisen of Oct. 7 contains a list of electric steel plants now in commercial operation.

Since we have noticed before in detail the industrial development in this country, we give in the following only a list of electric steel plants outside of the United States. We may mention, however, concerning this country that a Héroult furnace plant has been installed by the Firth-Sterling Steel Company at McKeesport, Pa., and that a Colby induction furnace is now in operation at Niagara Falls. We reserve further notes for a future issue.

HÉROULT FURNACE.

	Charge.	Power.
1. Richard Lindenberg, Remscheid, Germany.....	3,000 kg.	370 kw.
2. Richard Lindenberg, Remscheid, Germany.....	1,800 kg.	300 kw.
3. Bismarckhütte, Upper Silesia.....	3,000 kg.	400 kw.
4. Bismarckhütte, Upper Silesia.....	1,000 kg.	260 kw.
5. Deutsch-Oesterreichische Mannesmannröhren-Werke, Burbach.....	3,000 kg.	400 kw.
6. Danner & Co., Judenburg, Austria.....	2,000 kg.	300 kw.
7. Gebr. Böhler & Cie., Kapfenberg, Austria.....	2,500 kg.	350 kw.
8. Gebr. Böhler & Cie., Kapfenberg, Austria.....	Not yet decided.	
9. Georg Fischer, Schaffhausen, Switzerland.....	1,000 kg.	250 kw.
10. Georg Fischer, Schaffhausen, Switzerland.....	5,000 kg.	400 kw.
11. Georg Fischer, Schaffhausen, Switzerland.....	5,000 kg.	400 kw.
12. Soc. Electromet. Française, La Praz, Savoy, France.....	3,000 kg.	370 kw.
13. Acieries du Saut du Tari, St. Jéruy, France.....	5,000 kg.	600 kw.
14. Aktiebolaget Héraults Elektriska Stål, Korffors, Sweden.....	4,500 kg.	300 kw.
15. Società Tubi Mannesmann, Dalmine, Italy.....	6,000 kg.	736 kw.
16. Società Tubi Mannesmann, Dalmine, Italy.....	6,000 kg.	736 kw.

Nos. 1, 2, 5, 6, 7 the charge is liquid steel, while furnaces No. 9, 10, 11, 12, 13, 15 and 16 are charged with cold material. Nos. 5, 8, 10, 11, 15, 16 are in course of erection; the others are in operation.

STASSANO.

	Charge.	Power.
1. Bonner Fräsefabrik, Bonn.....	1,000 kg.	185 kw.
2. Bonner Fräsefabrik, Bonn.....	1,000 kg.	185 kw.
3. Forni Termoelettrici Stassano, Turin, Italy.....	5,000 kg.	750 kw.
4. Forni Termoelettrici Stassano, Turin, Italy.....	5,000 kg.	750 kw.
5. Forni Termoelettrici Stassano, Turin, Italy.....	900 kg.	180 kw.
6. Forni Termoelettrici Stassano, Turin, Italy.....	900 kg.	180 kw.
7. Forni Termoelettrici Stassano, Turin, Italy.....	400 kg.	75 kw.
8. Forni Termoelettrici Stassano, Turin, Italy.....	400 kg.	75 kw.
9. Forni Termoelettrici Stassano, Turin, Italy.....	700 kg.	150 kw.
10. Government Arsenal, Turin, Italy.....	700 kg.	150 kw.
11. Government Arsenal, Turin, Italy.....	700 kg.	150 kw.

Nos. 2, 7, 11 are in course of erection; the others are in operation.

KELLER.

	Charge.	Power.
1. Holtzer & Co., Unieux, France (No exact data known).....	...	...

DU CIEFFRE.

	Charge.	Power.
1. Soc. des Hauts-Fourneaux et Forges, Allevard, France.....	3,200 kg.	500 kw.
2. Soc. des Hauts-Fourneaux et Forges, Allevard, France.....	3,200 kg.	500 kw.

Nos. 1 and 2 are in operation.

GIROD.

	Charge.	Power.
1. S. A. Electrometallurg. Procédés P. Girod, Ugine, Savoy.....	1,800 kg.	300 kw.
2. S. A. Electrometallurg. Procédés P. Girod, Ugine, Savoy.....	2,000 kg.	300 kw.
3. S. A. Electrometallurg. Procédés P. Girod, Ugine, Savoy.....	2,000 kg.	300 kw.
4. S. A. Electrometallurg. Procédés P. Girod, Ugine, Savoy.....	8 to 10,000 kg.	1,200 kw.
5. S. A. Electrometallurg. Procédés P. Girod, Ugine, Savoy.....	8 to 10,000 kg.	1,200 kw.
6. Oehler & Co., Aarau, Switzerland.....	2,000 kg.	300 kw.
7. Joh. Cockerill & Co., Belgium.....	3 to 4,000 kg.	450 kw.
8. A. Storz, Stuttgart-Kornwestheim.....	2,000 kg.	300 kw.
9. Marrel Freres, Rive de Gier, France.....	Not yet decided.	
10. Ternitzter Eisen- und Stahlwerke, Ternitz, Austria.....	Not yet decided.	

Nos. 1 and 6 are in operation, the others in course of erection.

KJELLIN.

1. Röchling, Völklingen, Germany.....	8,500 kg.	750 kw.
2. Fried. Krupp, Essen, Germany.....	8,500 kg.	750 kw.
3. Oberschlesische Eisenindustrie, A. G., Gleiwitz, Germany.....	1,500 kg.	180 kw.
4. Poldihütte, Kladno, Bohemia.....	4,000 kg.	440 kw.
5. J. Brauns' Sohn, Vöcklabruck, Austria.....	400 kg.	65 kw.
6. Allg. Kalziumkarbid-Genossenschaft, Girttellen, Switzerland.....	?	330 kw.
7. Vidua de Urigoitia e Hija, Araya, Spain.....	1,500 kg.	215 kw.
8. Alti Forni Gregorini, Loreve, Italy.....	1,500 kg.	330 kw.
9. Iron Works Domnarfvet, Gysinge, Sweden.....	1,500 kg.	175 kw.
10. Metallurgiska Aktiebolaget, Trohatten, Sweden.....	2,000 kg.	300 kw.
11. Vickers, Sons & Maxim, Sheffield, England.....	550 kg.	150 kw.
12. Grondal-Kjellin Co., Nine Elms Lane, London, England.....	100 kg.	60 kw.

All the Kjellin furnaces are single-phase furnaces. Nos. 1 and 6 are no longer in operation; Nos. 8 and 10 are in course of erection. The others are in operation.

RÖCHLING-RODENHAUSER.

1. Röchling, Völklingen, Germany.....	Charge. 3,500 kg.	Power. 400 kw.
2. Röchling, Völklingen, Germany.....	8,500 kg.	750 kw.
3. Röchling, Völklingen, Germany.....	2,000 kg.	275 kw.
4. Bergische Stahlindustrie, Remscheid, Germany.....	1,500 kg.	500 kw.
5. Le Gallais, Metz & Co., Dommeldingen, Luxemburg.....	700 kg.	100 kw.
6. Le Gallais, Metz & Co., Dommeldingen, Luxemburg.....	3,500 kg.	300 kw.
7. Le Gallais, Metz & Co., Dommeldingen, Luxemburg.....	3,500 kg.	300 kw.
8. Le Gallais, Metz & Co., Dommeldingen, Luxemburg.....	1,500 kg.	275 kw.
9. Aciéries Liégeoises, Bressoux-les-Liège, Belgium.....	1,000 kg.	200 kw.
10. J. Knöpfel, Walzenhausen, Switzerland.....	1,000 kg.	175 kw.

Nos. 1, 2, 4, 5, 6 and 7 are single-phase furnaces; Nos. 3, 8, 9 and 10, three-phase furnaces. Nos. 2, 6, 7, 8, 9, and 10 are in course of erection; the others are in operation.

SCHNEIDER.

1. Schneider & Co., Creusot, France.....	Charge. 1,000 kg.	Power. ...
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SCHNEIDER-GIN.

1. (?) Plettenberg, Westf. (in course of erection).....	Charge. 4,500 kg.	Power. 400 kw.
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FRICK.

1. Fried. Krupp, A. G., Essen, Germany.....	Charge. 10,000 kg.	Power. 750 kw.
2. John Brown & Co., Sheffield, England.....	1,800 kg.	200 kw.
3. Wm. Jessop & Sons, Sheffield, England.....	3,000 kg.	450 kw.

Nos. 1 and 2 are in operation; No. 3 has been discontinued.

A. G. ELECTROMETALL, LUDVIKA.

1. Arvika, Sweden.....	Charge. 1,000 kg.	Power. 175 kw.
2. Hagfors, Sweden.....	500 kg.	125 kw.
3. St. John del Rey Mining Co., Brazil.....	2,000 kg.	300 kw.

No. 1 is in operation; Nos. 2 and 3 have been discontinued. All are three-phase furnaces. All the furnaces mentioned on this page are induction furnaces.

Electrochemistry at the Electrical Show.

The New York Electrical Show, held under the auspices of the large electric central station companies of Greater New York to commemorate the first quarter of a century of electric service in New York and fifty years of transatlantic communication by cable, was opened on Oct. 3, and during the ten days of its existence it attracted a very large attendance, especially during the closing days, although no free tickets had been given out this year.

The opening exercises on Oct. 3 were unique in so far as all the congratulatory and introductory speeches were made by phonograph. These seven speeches were made by Mr. Thomas A. Edison, president of the Show; Mr. Louis A. Ferguson, president of the American Institute of Electrical Engineers; Mr. William C. L. Eglin, president of the National Electric Light Association; Mr. W. W. Freeman, president of the Association of Edison Illuminating Companies; Mr. E. G. Acheson, president of the American Electrochemical Society; Mr. Henry A. Lardner, president of the New York Electrical Society, and Governor C. E. Hughes of New York State.

From Mr. Edison's speech we quote the following:

"The lesson of the jubilee of the Atlantic cable of 1858 is one of encouragement to all who would add to the resources

of our race and extend our control over the forces of nature. Never was failure more complete, never was higher courage shown, never was triumph more brilliant than that which since 1866 has kept the Old World moored alongside the New by pulsating cables of steel and copper—the 'family ties' of the civilized world.

"When I look around at the resources of the electrical field to-day as shown in this Exhibition, I feel that I would be glad to begin again my work as an electrician and inventor; and we veterans can only urge upon our successors, the younger followers of Franklin and of Kelvin, to realize the measure of their opportunities and to rise to the height of their responsibilities in this Day of Electricity."

Mr. Acheson's speech was as follows:

"Electrochemistry has furnished the fifth and latest important application of electricity, the other four being in the order of their development—telegraphy, telephony, lighting and traction. The Electrical Engineer and the Chemist having joined hands, we now have the new science—Electrochemistry, one devoted to the creation of new materials, and also the better and cheaper manufacture of others used in the world's industries.

"Electrochemistry, while one of the youngest of the sciences, has become one of the most important. National societies, devoted to its interests, already exist in the industrial countries of the world. Having made its appearance at Niagara Falls in 1895, it is now producing, at that center, aluminium, carborundum, carbide of calcium, caustic soda, bleaching powder, graphite, metallic sodium, metallic silicon, and other materials, the united value of their annual production amounting to several millions of dollars, and these are produced by the utilization of a very small fraction of the possible power of Niagara Falls.

"While the earlier applications of electricity have extended man's field of operation and increased his comfort, by the agency of electrochemistry, waste materials are being transformed into valuable products, thereby adding to the world's wealth and conserving our natural resources.

"I am pleased that this Exposition brings to notice some of the possibilities of this new and interesting science."

* * *

The New York Edison Company, the United Electric Light & Power Company and the Edison Electric Illuminating Company, of Brooklyn, as the organizers of the show, occupied large spaces, and the last two companies had arranged comprehensive, attractive and instructive exhibits.

The exhibit of the United Electric Light & Power Company was primarily intended to show the possibilities of alternating and polyphase currents. The exhibit of the Brooklyn Edison Company comprised three sections: a domestic section, showing the various uses of electricity in the kitchen and for numerous household appliances; a commercial section, illustrating the possibilities of electric illumination of haberdashery with show-window display; and a very instructive industrial section. In the latter a 25-hp gas engine, a 25-hp steam engine, and a 25-hp electric motor were shown side by side in operation. The arrangement brought out the points of superiority of electric driving in a very clever and forceful manner.

The most striking feature of the whole show was undoubtedly the brilliant illumination, and the most interesting feature of the illumination, from an engineering point of view, was the practical absence of the carbon lamp and the complete predominance of tungsten and other metallic-filament lamps, as well as of various types of new arc lamps with impregnated carbons. Very few of the thousands of visitors have probably thought of this feature in connection with electrochemistry. Yet it is, nevertheless, a fact that this revolutionary change in modern electric lighting methods is primarily the result of electrochemical and chemical research.

However, there was also a specific electrochemical exhibit of a comparatively small compass and by no means complete, yet interesting and instructive.

The chief corner of the electrochemical exposition was occupied by the **International Acheson Graphite Company** of Niagara Falls. Their exhibit, which was exceedingly attractive, had been arranged by Mr. E. G. Acheson himself and by Mr. W. Acheson Smith. It showed the enormous range of different industrial fields for which artificial graphite has become indispensable.

The now familiar applications of Acheson graphite for electrodes, dry-battery fillers, paint pigments, for electrolytizing, lead pencils, rifle lubrication, gear, cup and ball-bearing lubrication were, of course, shown. Among newer applications was the use of artificial graphite for pyrometer tubes.

The ease of machining artificial graphite makes it enormously useful for many purposes. Thus, the method of screwing one large graphite electrode into another one (so as to obtain a continuous feed of electrode and avoid any interruption of electric furnace operation) was shown. That it is possible to do almost anything with artificial graphite was indicated by some tiny, delicate elastic spiral springs cut out of a graphite tube. Another pretty exhibit was a baked amorphous carbon electrode for batteries of very delicate construction, which had been artificially graphitized.

There were, of course, also exhibits of aquedag and oilclag, i. e., deflocculated graphite suspended in water or oil (our Vol. V, page 452, which are now becoming important lubricants).

A small, but particularly interesting exhibit of Mr. Acheson were three reguli of aluminium, since they had been made by reduction of alumina with carbon in the electric furnace.

The exhibit of the **Norton Company**, of Worcester, Mass., occupied the next table. It had been arranged in an artistic manner by Mr. H. K. Dodge, New York manager of the Norton Company. As is well known, this company makes alundum, i. e., artificial emery, by fusion of bauxite in electric furnaces in their Niagara Falls works.

Their exhibit included samples of natural bauxite and of regular, white and blue-black alundum. There were also 13 bottles, containing alundum in grains, showing the various sizes used in the manufacture of grinding wheels. As finished products were shown seven small grinding wheels of different kinds made of alundum, five specimens of rubbing and sharpening stones made of alundum, and two sheets of alundum cloth. The manufacture of artificial emery in the electric furnace has, indeed, undergone a very interesting and successful development during the last seven years under the care of the Norton Co.

The **Aluminium Company of America** of Pittsburgh had a fine exhibit. As is well known, this company is the sole producer of aluminium in this country, using the process of Mr. Charles M. Hall. Through his kindness and that of the chief chemist of the company, Mr. E. Blough, this exhibit had been procured. It was well representative of the smaller-sized commercial articles manufactured from aluminium at present.

The exhibit of aluminium castings included pipe fittings, meter frames and covers, etc. Aluminium tubing, samples of which were shown, should be especially interesting to our readers, since it is coming into wide use in the chemical industries, especially for acetic acid manufacture, nitric acid condensers, sulphide pulp mills, ammonia concentrators, etc. Aluminium cables were exhibited bare, insulated and lead-covered. The McIntire joint was shown. Quite interesting were bimetallic wire with a steel core and an envelope of aluminium and bimetallic tubing, containing aluminium inside and copper outside. Various aluminium shapes were shown for use on automobiles, trolley shoes, etc.

An apparently new industrial development is the drawing and spinning of aluminium. It can be drawn into forms with few operations and little annealing, yet when of proper temper or suitably alloyed a very stiff finished product is obtained. Perhaps most interesting to the general public was an exhibit showing the evolution of an aluminium coffee pot from blank plate to finished product in five operations.

Right next to the aluminium exhibit was that of the **Gold-**

schmidt Thermit Company of New York City, which had been kindly placed at the disposal of the show by Mr. E. Stutz, vice-president and general manager of the company, and had been arranged by the manager of their sales department, Mr. W. H. Hulbert. Samples of the following metals, free from carbon and made by the aluminothermic process, were exhibited: chromium, manganese, molybdenum, manganese-copper, manganese-zinc, manganese-tin, ferrovanadium, ferrotitanium and ferroboron.

There were also shown samples of ordinary black thermit, nickel thermit and manganese thermit and a can of ignition powder. A tripod and automatic crucible, ready for a weld, were also exhibited, as well as finished pipe welds and a sample of the compromise rail weld. In addition, there were four photographs showing a number of large thermit welding operations, carried out in practice.

The **Castner Electrolytic Alkali Company** of Niagara Falls, through the kindness of their general manager, Mr. Max Mauran, exhibited samples of their caustic soda and bleaching powder. One sample of the caustic soda was crystalline, showing the long grain and lustrous fiber peculiar to the high-strength caustic made by the Castner mercury-cathode process. The other sample showed caustic molded in form of sticks for laboratory use. This caustic is 99.5 per cent pure. The bleaching powder tests 37½ per cent available chlorine.

The **Union Carbide Company** and the **Electro Metallurgical Company** of New York City, through the courtesy of their general manager, Mr. E. F. Price, and of the chief metallurgist of the latter company, Mr. Fred. M. Becket, exhibited three jars of calcium carbide and three lumps of ferrochromium, ferrosilicon and ferrovanadium low in carbon.

The **American Cyanamide Company** of Nashville, Tenn., exhibited a sample of calcium cyanamide, made from calcium carbide. The company has made some improvements in the product they propose manufacturing, as compared with the product manufactured in Europe. In deference to the requirements of the fertilizer trade, they have reduced the content of ammonia, and have also converted the free lime present in cyanamide into land-plaster. They are now erecting a plant in Niagara Falls. We intend to give further notes on this interesting development in the near future.

The **Carborundum Company** of Niagara Falls, through the kindness of their works manager, Mr. F. J. Tone, exhibited a beautiful lump of carborundum crystals and a large sample of metallic silicon, made in the electric furnace.

The **United States Metals Refining Company** of Chrome, N. J., through the courtesy of their superintendent, Mr. Lawrence Addicks, exhibited a series of very interesting samples showing the different stages of the metallurgy of copper from ore to insulated copper wire. There were samples of copper sulphide and copper carbonate ores, copper matte, anode copper and cathode copper, etc., and samples illustrating the evolution of insulated wire from wire bar.

The **Hoskins Company** of Chicago had an exhibit of various small electric furnaces, which was particularly interesting, since their Eastern manager, Mr. M. M. Kohn, 205 Postal Telegraph Building, New York City, was present every night and showed the furnaces in operation to an always large and interested attendance. The furnaces exhibited were an electric combustion tube furnace (particularly suitable for rapid determination of the carbon content of steel by the direct method), an electric muffle furnace (useful for all purposes for which the muffle is adapted, and, in addition, for steel manipulation for optical works, for baking and enameling porcelain, etc.), and a combination furnace which can be used as a crucible furnace or muffle furnace.

There was also a very interesting historical exhibit, contributed by Dr. Chas. A. Doremus and relating to the work of Joseph Henry, Robert Hare, Moissan and Berthelot.

An account of other exhibits at the Show will be found on page 475.

Grinding Mill with Air Separation.

As the grinding, pulverizing and separating machinery of the Raymond Brothers' Impact Pulverizer Company, of Chicago, has been briefly noticed before repeatedly in our columns, the following more detailed description of their mills, with some results obtained recently in commercial practice, should be interesting to engineers in those numerous chemical and metallurgical industries in which fine grinding and great uniformity of the ground product are matters of prime importance.

The Raymond Brothers' Impact Pulverizer Company has specialized for a great many years in fine grinding, meaning 70 mesh and finer down to 200 mesh and impalpable powder. A single one of their special fields is the lime grinding industry in the large beet sugar plants all over this country, where the lime is ground so that between 90 and 100 per cent passes a 200-mesh test sieve. But similar results are desired or required also in a great many chemical industries.

The fundamental feature of the Raymond system is the

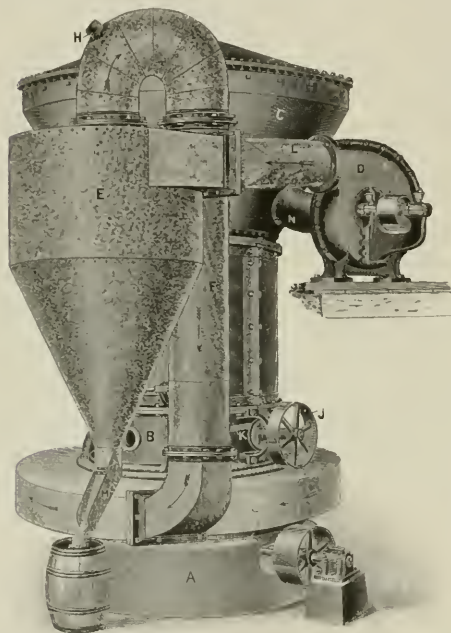


FIG. 1.—GRINDING MILL WITH AIR SEPARATION.

principle of air separation. It is an exceedingly simple principle, based on the fact known from every-day life, that a current of air passing over fine particles of material in form of dust or the like will carry these particles along, and that with an increase in the speed of the air current proportionally heavier particles will be picked up.

Fig. 1 shows the typical Raymond roller-mill plant. *A* is the foundation of concrete, timber, or simply a good, strong floor. *B* is the roller mill. *C* is the vacuum separator, which varies in size from 6 to 16 ft. in diameter; the finer the product required, the larger is the separator.

D is the exhaust fan. (As shown in Fig. 2, it can be set so as to exhaust from top of separator.) *E* is the galvanized-steel dust collector and settling chamber, which can be set higher so as to discharge into a storage bin if desired. *F* is the return air pipe. *G* is the galvanized-steel housing around the mill, to conduct the return air into the pulverizing chamber.

H is the vent pipe, to relieve back pressure or to relieve the system from any surplus air that might enter with the feed or any opening provided to admit air from the outside. This pipe usually leads to a small dust room or any suitable dust collector.

M (at the bottom of the settling chamber *E*) is the discharge spout for the finished product.

The roller mill crushes and grinds the material by gravity and centrifugal force. A plow is located ahead of each roller and constantly throws a stream of material between the face of the roller and the ring die.

In the mills with air separation, the air enters the mill through a series of tangential openings around the pulverizing chamber directly under the ring die and rollers, and that portion of the material which is reduced to the required fineness by the rollers passing over it once is instantly carried away by the air current, but that which is not fine enough drops down, is caught by the next plow following and carried between the succeeding roller and the ring die, to receive like treatment. If the mill is kept properly filled with material, each of the plows will throw

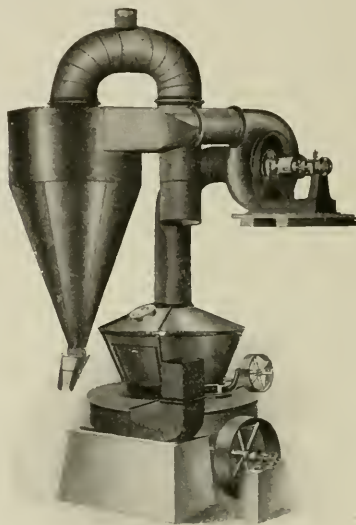


FIG. 2.—ROLLER MILL WITH AIR SEPARATION.

a constant stream between the two grinding faces, preventing direct contact of roller and ring die.

An interesting feature of the construction is that the casting supporting the plows is attached to the slow speed upright shaft, and very little power is required to raise the material and throw it between the crushing surfaces of the roller tire and the ring die.

The plows can be removed or adjusted by simply opening one of the doors and without taking the machine apart, and the construction of the mill permits the face of the rollers to remain always parallel with the face of the ring die.

Fig. 2 shows the latest form of the Raymond standard four-roller mill, with the rollers suspended and the pneumatic separator with a revolving disk taking the place of the inner cone in the standard separators. The suspended roller mill has been on the market so long that its merits are known to all engineers. The only difficulty heretofore has been that the mill was surrounded by a screen, through which the material had to pass, and when a fine finished product was desired it became necessary to use a fine mesh screen or bolt the material outside the mill, returning the tailings. The expense and trouble of bolters

are well known, and a sufficiently fine screen in the mill would on most materials clog, or at least so greatly reduce the mill's capacity as to lessen its economy. By attaching the air separator and admitting the air to the mill underneath the grinding surface, the material is taken away by the air current, as fast, and faster than it is reduced; the separator returning the coarse material to the mill in a continuous stream, from the edge of the revolving disk, over which a thin sheet of air at high velocity is constantly passing, separating the fine powder. These features give the mill very high capacity, and at the same time insure a finished product of uniform fineness.

One of these four-roller mills has just been installed in the works of the Pennsylvania Cement Company at Nazareth, Pa. This mill requires only from 65 to 70 hp and grinds $6\frac{1}{2}$ tons per hour, 97 $\frac{1}{2}$ per cent passing through a 100 mesh and 92 per cent through a 200 mesh. The large proportion of the 200-mesh product or fine powder is remarkable. The mill is fed with material crushed only to 1 in., some of it to $1\frac{1}{2}$ to 2 in. in size.

Last winter the Raymond company installed nine mills in the raw grinding department and three mills in the coal grinding department of the new Huron Portland Cement Company's plant at Alpena, Mich. The following figures are taken from the daily reports of the first six days in September:

	Raw material.	Coal.
Sept. 1	98.4%	98.4% passed 100 mesh
Sept. 2	98.2%	98.3%
Sept. 3	98.5%	98.5%
Sept. 4	98.4%	98.5%
Sept. 5	98.4%	98.6%
Sept. 6	98.6%	98.6%

These figures show the great uniformity of fineness of the product obtained from day to day. It is stated that these results have been the same every day since the mills were started last spring.

A New Chemical Stoneware Factory.

The works of the Didier-March Company, which were recently finished, are located on the Raritan River at Keasby, near Perth Amboy, N. J., and are readily accessible both by water and rail, permitting of economical and rapid delivery under all conditions.

The mines, furnishing an extensive variety of domestic clay, are located in the immediate neighborhood of the factory buildings, thus enabling the raw materials to be handled at minimum

Experiments are continually being made to find combinations of raw materials superior to any heretofore discovered. In many cases in the manufacture of both acid-proof and highly refractory products specific requirements prohibit the introduction of domestic clay. For these cases use is made of an extensive stock of raw material obtained from the special clay deposits of Germany and Sweden. It is thus possible to make articles in every particular equal to those manufactured abroad, without the almost prohibitive expense and loss of time unavoidably attached thereto. Intimate connection between the Didier-March Company and the Deutsche Ton & Steinzeug Werke, and also the Stettiner Chamotte Fabrik A.-G., insures a ready adaptation of the latest European inventions and processes to American conditions.

The building used for the manufacture of chemical and electrolytic pottery ware is a thoroughly modern steel and concrete structure designed especially for the purpose, and absolutely fireproof. Machinery of the most modern and efficient type has been imported from abroad and represents the result of years of practical experience. As far as possible, manual labor has been supplanted by machinery, resulting not only in a considerable decrease in the cost of production, but also in a more uniform product. With a view of minimizing the actual operating expenses, entirely mechanical conveying appliances are used for transporting the raw material, both before and after the process of preparation, as well as the finished products.

In order to allow of manufacturing the latest and most intricate apparatus for the chemical industry, an extensive model room is provided, equipped with the most modern appliances.

Ample kiln capacity is provided, thereby insuring rapid deliveries of the great variety of articles manufactured. In order to obtain the maximum economy in the process of burning, a modern type of square down-draft kilns has been erected, which embody all the improvements made during years in the largest plants of Europe.

Besides manufacturing the many apparatus regularly required in the chemical industries, as noticed in the catalog of the Didier-March Company, apparatus of special and intricate form can be executed at short notice. Among these may be mentioned all the necessary apparatus required in the manufacture of sulphuric and sulphurous acids; hydrochloric and nitric acids; explosives (after the system of Griesheim, Guttman, Valventiner, Uebel, Thomson and others); chlorine; bromine; iodine; formaldehyde; acetic acid, etc.; also complete denaturation and regeneration plants, constructed according to patented



WORKS OF THE DIDIER-MARCH COMPANY IN KEASBY, N. J.

cost. For the accommodation of the employees of both the refractory clay and pottery departments, a number of cottages are provided. This promotes a considerably greater interest of the employees in their daily work than would otherwise be the case.

In order that the manufacture of both the pottery and refractory clay products may be carried on along strictly scientific lines, an extensive chemical and physical laboratory has been established, under the supervision of a trained chemical engineer, which makes it possible to scientifically determine the requirements of the many special uses to which clay products are now subjected.

processes, for which the Deutsche Ton & Steinzeug Werke, of Charlottenburg-Berlin, Germany, and the Didier-March Company are the exclusive makers of the stoneware parts.

Ore Concentration.—The National Ore Concentration Company, of Chicago, have sent us their bulletin on the Woodbury system of ore concentration. In this the "preliminary separation," by means of classifiers, screens, etc., is largely eliminated, the classifying and jigging operations being combined into one. A new plunger jig has been developed from the older types of jigs, of greatly increased capacity and capable of treating unclassified ores.

Reversion Recorder for Regenerative Furnaces and Coke Ovens.

The progress which has been made in recent years in the methods employed by the steel industry is well illustrated by the extensive use of exact measuring instruments, like pyrometers, and by the further tendency of employing recording rather than indicating instruments.

A recording instrument furnishes at once a full and permanent record of the operation. A comparison of the charts obtained every day reveals immediately any irregularities, which may then be at once investigated. At the same time the chart serves as an admirable timekeeper; the furnace man is permanently under the control of the recording instrument.

A new development along this line is the Sarco Reversion Recorder for regenerative furnaces and coke ovens, made by the Sarco Fuel Saving & Engineering Company, West Street Building, New York City. This instrument, constructed on strictly scientific principles, produces a permanent record of each reversion of the gas valves on regenerative furnaces, the

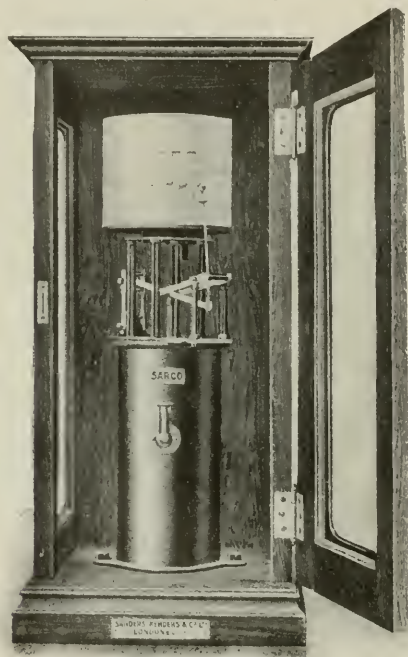


FIG. 1.—REVERSION RECORDER.

exact time when it takes place and, further, the draught and gas pressures at the time.

The construction is as follows: The cylindrical body of the instrument contains a bell, floating in glycerine. The air space above this bell is kept under atmospheric pressure by means of a small opening in the instrument; a tube enters from below and extends above the level of the glycerine into the air space under the bell, which is otherwise sealed. This tube is connected to a pipe, tapping one of the gas flues between the regenerator and the reversing valve, and thus any variation in the pressure in the same will cause the bell to rise or fall, as the case may be. This motion is transmitted to a pen by means of a small rod, as shown in the illustration, and a very sensitive parallel gear, and the pen in its turn registers the changes in the pressure on a continuous chart placed on a drum fitted with a clockwork.

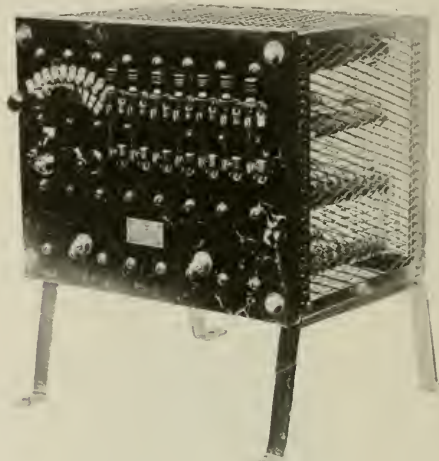
The chart on which the record is plotted is divided by a center zero line, and the pressure existing in the flue at the time gas is passed through is recorded by a horizontal line below zero. At the moment of reversing, the pen will rise above the zero line and register the suction then created by the draught from the chimney.

Thus not only the gas and air pressures are measured, but a diagram is produced which shows, at a glance, whether the valves have been reversed regularly and at the proper time.

Laboratory-Rheostat.

The Ward Leonard Electric Co., of Bronxville, N. Y., has just placed upon the market a laboratory rheostat of large capacity, which is at the same time fool-proof. It is shown in the adjoining illustration.

There has long been a demand for a rheostat which may be



RHEOSTAT.

connected directly to the supply voltage and by means of which it is possible to get any desired amperage. The Ward Leonard rheostat is designed for a maximum current of 56 amp, and the current may be adjusted in steps of 0.1 amp from 0.1 to 56 amp. The rheostat can be used both on direct-current or alternating-current circuits. It has a non-inductive resistor with practically zero temperature-coefficient of resistance.

The system of the connections is exceedingly simple. Each resistor with its controlling switch is designed to be connected across the full line volts. Each switch is marked with the number of amperes that will flow when it alone is closed. Any desired reading can be obtained by closing the proper switch or switches. As each resistor is designed to carry the full line volts, "burn-outs" are impossible, and overload protective devices for preventing accidents to the rheostat are unnecessary.

The resistor portion is 10 in. x 12 in. x 15 in. over all. It can be mounted on the side wall out of the way. The face plate or controlling portion is only 14 in. x 8 in. It can be mounted on the test table, inside the cover of the desk, etc. Unless otherwise specified, however, the complete rheostat is furnished as shown in the illustration.

The resistor elements are built up of Ward Leonard enameled resistor units, millions of which are in service. They are fire-proof, strong, of light weight, and are thoroughly protected against injury from mechanical, electrical and chemical causes. It is stated that this is the first "fool-proof," heavy-duty

rheostat that has ever been placed upon the market for laboratory service, giving very fine gradations for control of the current.

Some Exhibits at the New York Electrical Show.

On pages 470 and 471 of this issue a full account is given of the special electrochemical exhibit at the recent Electrical Show in Madison Square Garden. In the following we give notes on some other exhibits which should be particularly interesting to chemical and metallurgical engineers.

The **Goulds Manufacturing Company**, of Seneca Falls, N. Y., had an interesting exhibit of triplex pumps, in charge of Mr. William H. Kemp. The different methods of driving pumps by electric motors, either by direct connection or by belt connection or through reduction and worm gearing, were shown. Of special interest was a working exhibit of a pump lifting water into a tank fitted with a float switch, thus showing the automatic feature of the set. While the pumps exhibited were for ordinary use, it is interesting to note that the Goulds Manufacturing Company also make a specialty of pumps for chemical and metallurgical purposes. For instance, the plant of the Solvay Process Company is equipped with special forms of Goulds triplex power pumps, specially designed and built for handling three different chemical solutions at the same time, saving space and power.

Another pump exhibit was that of the **Watson-Stillman Company**, of New York, in charge of Messrs. Edward Johnson, James Hargan, and Harry Printel. This company showed six electrically-driven pumps, differing in size, and also hydraulic jacks and shaft straighteners in operation. They also build special pumps for chemical and metallurgical work.

The **Heany Fireproof Wire Company**, of York, Pa., exhibited their asbestos-covered wire which should be of great advantage wherever an electric wire is subjected to a high temperature, which would be dangerous in case ordinary wire were used. This fact makes the asbestos wire especially applicable in close proximity to furnaces, etc., but also in such cases where there is liability of heavy overloads producing excessive heat inside the wires. An interesting little piece of the exhibit which was in charge of Mr. W. A. Ernst, was an asbestos-covered wire in which the inner copper conductor had been caused to melt by a heavy electric excess current, without destroying the surrounding asbestos envelop.

The pure asbestos is applied to the wire by a special process of Mr. Heany and the only foreign material used in this insulation is the inorganic fireproof and waterproof compound by which the asbestos is cemented to the wire. The wire has been found to be able to withstand too per cent overload in heavy street railway machinery. Since similar severe conditions as in traction are experienced in the power supply of steel mills and in metallurgical works in general, the asbestos-covered wire should prove of service for such work. It is self-evident that it should be particularly useful for such special cases as the magnet windings of induction furnaces.

The **Driver-Harris Wire Company**, of Harrison, N. J., had an interesting exhibit of their special resistance wires, in charge of Mr. A. Bensel. The special feature was a sign, made of their "nichrome" wire which although continually heated by electric current to red heat, was shown not to oxidize. Nichrome is an alloy of nickel and chromium; its characteristic features are the ability to withstand high temperatures up to 1500° F. without oxidation, and the facts that it is practically non-corrosive and will not become brittle with repeated heating and cooling. Its specific resistance is 375 ohms per milfoot, with a temperature coefficient of 0.0024 per degree F. It is furnished either in ribbon or wire form and should prove very useful as resistor for certain types of resistance furnaces.

Another special resistance alloy of the Driver-Harris Company is "climax" (a special nickel steel), which has a resistance 50 times that of copper. Unlike German silver, climax

does not become brittle with repeated heating and cooling.

Still another special alloy of this company is "advance," a copper nickel alloy, containing no zinc. Its specific resistance is 28 times that of copper and its temperature coefficient is practically nil. It does not become brittle with repeated heating and cooling and is non-corrosive. This alloy is chiefly used in measuring instruments, resistance units, motor starters, etc.

The company's complete line includes many special alloys. Among those exhibited were manganine, German silver, and ferro-nickel.

The **Habirshaw Wire Company**, of Yonkers, N. Y., had a large and fine exhibit of wires and cables for various voltages and amperages. While the feature of the exhibit was a sample of the largest telephone cable built for submarine purposes, there were also shown numerous samples of cables for power transmission, including the cable used at Niagara Falls. The exhibit was in charge of Mr. James B. Olson and Mr. Carl F. Obermaier.

The **Murphy Electricity Rectifier Co.**, of Rochester, N. Y., exhibited a new machine for charging alternating into direct current. This should be useful for all cases where direct current is needed for electrolytic work, for instance, for electroplating, for charging storage batteries, etc., while only alternating current is available from the town-supply circuits. The usual methods employed now in such cases, are to install either a motor-generator or rotary converter or a rectifier either of the electrolytic type with aluminium electrodes or of the mercury-vapor tube type. The new apparatus, exhibited by Mr. T. J. Murphy, who was himself in charge of the exhibit, may perhaps be called a mechanical rectifier, since the rectifying effect is obtained mechanically by a special commutator. This is driven by a small synchronous motor. It is expected that the apparatus will soon be placed on the market.

The **General Electric Co.**, of Schenectady, had a very fine exhibit, showing its multifarious interests. Among the representatives present were Mr. F. H. Gale, Mr. W. C. Andrews, and many others. The features of their exhibit was the tungsten lamp and their electric heating apparatus. A 35-kw Curtis turbine set was also exhibited.

The exhibit of the **Electrical Testing Laboratories**, of New York City, had various instructive and even spectacular features, including an insulator-testing plant in operation. The test current was supplied from a 250,000-volt transformer. The spherical photometer, which enables the determination of the candle-power of a lamp by a single measurement, was shown with the Sharp-Millar photometer. The essential differences between the carbon arc, the magnetite arc, and the flaming arc, were nicely shown by projecting them side by side on a screen. The exhibit was in charge of Mr. McDonald.

Zaremba Company.

Mr. Edward Zaremba, formerly manager of the American Foundry & Machinery Company, builders of the Swenson evaporator, has organized the Zaremba Company to build evaporators of the new Round-Body Type and also other styles of single and multiple effects. Besides evaporators it will furnish vacuum dryers, diffusion and leaching batteries and various types of chemical machinery.

The engineer of the new concern, Mr. Otto Mantius, has had a wide experience in the above lines in Germany, France and Belgium.

It will be the policy of the Zaremba Company to treat every proposition strictly with reference to the customer's conditions, building in each case the most suitable form of apparatus.

The headquarters will be at the Monadnock, Chicago.

Obituary.

We regret to report the death of Mr. George G. Blackwell, senior member of George G. Blackwell, Sons & Company, Ltd., in Liverpool, England, on Aug. 26.

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.
ELECTRIC FURNACES (Continued).

571,655, November 17, 1896, Adam Charles Girard and Ernest Auguste Georges Street, of Paris, France.

Arc type. The furnace chamber is a vertical carbon tube, having at its top a hopper with sealed cover, and surrounded by a refractory block encased with metal. Horizontal carbon electrodes extend through side openings nearly to the tube. An arc is sprung from one electrode to the tube and thence to the other electrode. Gas may be supplied through an opening at the top, or through holes in the electrodes. The product is discharged from the lower end of the carbon tube or through a lateral tap-hole. Also illustrates a furnace in which the carbon tube passes through alined openings in the ends of parallel carbon plate-electrodes, the arcs being magnetically rotated as in patent No. 555,626.

572,312, December 1, 1896, Edgar F. Price, of Newark, N. J. Arc type. The furnace is a tilting structure having an open top and end, through which the molten product is discharged into a receptacle clamped against the bottom of the furnace. The hearth and three sides of the smelting chamber are carbon slabs, the sides having outer walls. A hopper is supported on the upper edge. Five vertical, independently-adjustable carbon electrodes are arranged in a longitudinal series, arcing to the carbon hearth. Each electrode is surrounded, near its middle, by a water-cooled case. The charge-mixture gravitates downward between the electrodes and cases. The spaces between the cases open into flues leading to a condenser and stack.

573,041, December 15, 1896, Martin Schindler, of Neuhausen, Switzerland.

The furnace is a pot having a carbon hearth-electrode receiving a depending carbon electrode. This electrode may be square or circular in cross-section. The square electrode has a holder and terminal consisting of two parts having half-seats and bolted together. The holder for the circular electrode is annular and has a downwardly-extending flange. Tortuous or spiral cooling-passages are provided in the holders, through which cold atmospheric air is circulated. The carbon hearth may also be secured in a metal base having cooling passages.

575,115, January 12, 1897, Alfred E. Hunt, of Pittsburg, Pa. Resistance type. Heats a cast-iron mold, serving as a resistor, in order to produce sound castings of intricate shape, especially of aluminum. The mold has two annular contact pieces, one fixed to its upper end and the other vertically adjustable. The mold rests on a plate of asbestos. Before casting, the mold is heated by passing a current of electricity through it. After the metal is poured, the lower contact is slowly moved upward and a water or air blast is applied to the base of the mold, so that the metal cools progressively from the bottom to the top.

NEW BOOKS.

THE MINERAL INDUSTRY. Vol. XVI for 1907. 1127 pages, illustrated. Bound in cloth. \$10. New York: Hill Publishing Co.

COAL: ITS OCCURRENCE, VALUE, AND METHODS OF BORING. By R. Redmayne. 215 pages, illustrated. (Modern Practice in Mining.) Bound in cloth. Price, \$2 net. New York: Longmans, Green & Co.

A TEXT BOOK OF EXPERIMENTAL CHEMISTRY. By Edwin Lee. (For students of general inorganic chemistry.) 433 pages, 57 illustrations. Bound in cloth. Price, \$1.50 net. Philadelphia: P. Blakiston's Son & Co.

A TEXT BOOK OF PHYSICS. By A. Wilmer Duff, Karl E. Guthe, William Hallock, E. Percival Lewis, Arthur W. Goodspeed, Albert P. Carman, and R. K. McClung. 680 pages, 511

illustrations. Bound in cloth. Price, \$2.75. Philadelphia: P. Blakiston's Son & Co.

ELEMENTS OF PHYSICS. By G. Arthur Hoadley. 467 pages, illustrated. Bound in cloth. Price, \$1.20. New York: American Book Co.

ELECTRIC LIGHTING AND POWER DISTRIBUTION. By W. Perren Maycock. (An elementary manual of electrical engineering.) 619 pages, illustrated. Bound in cloth. Price, \$1.90 net. New York: Macmillan Co.

POCKET BOOK OF ELECTRIC HEATING AND LIGHTING. By Sidney Ferris Walker. (Comprising formulae, tables, rules and data.) 416 pages, illustrated. Leather binding. Price, \$3. New York: Norman W. Henley Publishing Co.

PUBLIC WATER SUPPLIES. By E. Eugene Turneure and Russell Harry Luman. (Requirements, resources, and the construction of works; with a chapter on pumping-machinery.) By D. W. Mead. 825 pages, illustrated. Bound in cloth. Price, \$5. New York: John Wiley & Sons.

HINTS FOR CRYSTAL DRAWING. By Margaret Reeks. With a preface by J. W. Evans. With illustrations by the author. 108 pages. Bound in cloth. Price, \$1.10 net. New York: Longmans, Green & Co.

COLOR PHOTOGRAPHY, AND OTHER RECENT DEVELOPMENTS OF THE ART OF THE CAMERA. By C. Holme. 123 pages, over 100 illustrations. Paper binding. Price, \$3 net. New York: John Laue Co.

THE GEOLOGY OF COAL AND COAL-MINING. By Walcot Gibson. (Arnold's geological series; general ed. J. E. Marr.) 351 pages, illustrated. Bound in cloth. Price, \$2.50. New York: Longmans, Green & Co.

THE WIMSHURST MACHINE: HOW TO MAKE AND USE IT. By Alfred W. Marshall. 112 pages, illustrated, 12mo. Paper binding. 25 cents. New York: Spon & Chamberlain.

MOTOR REPAIRING FOR AMATEURS. By J. H. Knight. 104 pages, illustrated. Bound in cloth. Price, \$1 net. New York: Spon & Chamberlain.

BOOK REVIEW.

METALLURGY: A CONDENSED TREATISE. Henry Wysor, Assistant Professor of Analytical Chemistry and Metallurgy in Lafayette College. 8vo.; 308 pages; 88 illustrations. Price, \$3.00. Easton, Pa.: The Chemical Publishing Company.

There was a need for just such a brief presentation of the art of extracting metals from their ores, for the use of college students beginning the subject and for the general public. There were, before this, books professing to answer these purposes, but they were mostly written by specialists, who gave prominence in them to this or that branch of the metallurgical art, at the expense of other divisions of the subject, and thus produced poorly balanced treatises. The chief merit of Mr. Wysor's book is its good balance, its equal treatment of all parts of the subject.

Without enumerating all the chapters, we may say that the work discusses the following topics: Physical properties of the metals, alloys, welding, plating, refractory materials and fluxes, theory of combustion, measurement of temperatures, natural fuels, artificial fuels, ore dressing, furnaces, metallurgy of iron and steel, copper, lead, zinc, tin, mercury, silver, gold, nickel, aluminium, manganese, chromium, tungsten, molybdenum, vanadium and platinum.

With all this condensed into three hundred pages, the treatment of each topic is necessarily brief, but it is very well condensed. The choice of the most important facts to present is excellent, and, although there are a few slips as to facts, yet the whole is so generally accurate and reliable that one would look in vain for a more satisfactory work on the subject condensed into such small compass.

Electrochemical and Metallurgical Industry

VOL. VI.

NEW YORK, DECEMBER, 1908

No. 12.

Electrochemical and Metallurgical Industry

With which is incorporated Iron and Steel Magazine

Published Monthly by the

ELECTROCHEMICAL PUBLISHING COMPANY

239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

J. W. RICHARDS, PH. D.....President
E. F. ROEBER, PH. D.....Editor and Secretary
C. E. WHITTLESEY.....Treasurer

Yearly subscription price for United States, Mexico and United States dependencies, \$2.00; for all other countries, \$2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

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New York Meeting of the American Electrochemical Society.

It has been truly said of the meetings of the American Electrochemical Society that they are always bristling with good-fellowship. If the Society had done nothing but created the esprit de corps which is now so characteristic of the whole electrochemical fraternity, its formation would have been justified. But with every new meeting it becomes more and more manifest that the Society has to fulfill a greater and even more important mission. The remarkable increase in membership during recent months indicates that the Society draws members from all quarters—electrical engineers as well as chemical engineers and metallurgists. The Electrochemical Society acts as a bond between these different interests. For this reason general discussions on subjects of broad interest are greatly to be recommended. There were two at the last meeting. The discussion on the possibility of using electrochemical and electrometallurgical processes for filling out the valleys in the central-station load-curve did not bring any clear-cut results. Nevertheless, the discussion was valuable, as it gave both sides an opportunity to speak their mind freely. If anything is to be accomplished, continuous agitation will be necessary. It is probably true that in the past there has been too much dreaming about possibilities and not enough clear understanding of the other fellow's needs. And as was suggested by one speaker, it may be that to make a success, the two sides must become a unity, i. e., the central station must carry out electrochemical and electrometallurgical processes itself. This would, indeed, be a logical development. If it should be proven that chemical or metallurgical industries can make use of the surplus power of the central station and make a profit, why should the central station not undertake the work itself? The chemical products would then be by-products of the power-generating business of the central station.

* * *

The second general discussion related to the important problem of the corrosion of iron and steel. In spite of its length, the discussion was not and could not be exhaustive, but some important points were brought out clearly and some problems formulated sharply. It seems that in the near future the metallurgy of iron and steel will be one of the principal subjects of practical electrochemical work; and the two important subjects of specifically electrochemical interest are corrosion of iron and steel and manufacture of steel in the electric furnace. It is an excellent proposition to devote a whole day of the next meeting to be held next Spring at Niagara to the electrometallurgy of iron and steel. At the New York meeting the only paper bearing directly on this subject was Mr. FitzGerald's account of the results obtained with the Lash process in the electric furnace at Niagara. One point stands out now more clearly than ever—that a certain process may be carried out as

well in one as in another type of electric furnace. There are essentially two types only. One is for simply melting together ingredients without any chemical refining action. This type is represented by the induction furnace. The other intends to refine steel by removing impurities by chemical reaction between them and the slag. For this purpose a number of different electric furnace constructions is suitable; they all are characterized by the fact that the heat can be easily controlled, and above all other things, that the reaction is carried out in a neutral or reducing atmosphere. This last point is the essential point which distinguishes the electric steel process from older steel processes. Among other interesting papers presented at the meeting we may call attention to Mr. Hering's valuable paper on heat loss through furnace walls. A full account of the convention will be found elsewhere in this issue.

Fixation of Atmospheric Nitrogen.

The old dream of electrochemists—the fixation of atmospheric nitrogen—seems gradually and slowly to become true. The problem is very simple: the immense quantity of nitrogen in atmospheric air is inert and useless in its elemental form; if forced into the form of a compound—nitric acid or a nitrate—it would be immensely useful for many purposes in peace and war, as a fertilizer and for explosives. The simplicity of the problem, thus stated, is matched by the difficulty of its solution. If we look backwards we find a long series of researches, many attempts and many failures. It is only in recent years that commercial success has been achieved in isolated cases under special conditions. Most attempts have been in the direction of combining directly the nitrogen and the oxygen in the air by means of electric discharges. This was attempted by Bradley and Lovejoy on a large scale at Niagara, but this process proved a commercial failure. Similar in principle (heating to a high temperature by the arc and then suddenly cooling), but using a quite different and much simpler apparatus, is the Birkeland-Eyde process. As repeatedly noticed in our columns this has proven a commercial success in Norway, under most favorable conditions of cheap power (stated to cost \$5 or so per horse-power-year). The Notodden plant, which has been working successfully in the past with a capacity of 40,000 kw, is now to be enlarged—the addition reported being not less than 200,000 hp.

* * *

While the Birkeland-Eyde process seems to be an electric-furnace process pure and simple—the arc having no other function but to heat the air to a very high temperature—it appears to be different with the process which is being developed by the Badische Anilin und Soda Fabrik. In their process there seems to be a specific electric effect, as distinguished from the purely thermal effect. They employ an arc in a long tube through which air is passed in a whirling motion. Since 1907 they have operated an experimental plant of 2000 hp and are now planning the erection of a large 120,000-hp plant. Their apparatus is distinguished by greatest simplicity, while the process, if really involving a specific electric besides the thermal effect, would have important advantages over purely thermal processes, as is pointed out in our American Electrochemical Society convention report in this issue in connection with the

paper of Professor Morden. Undoubtedly the process having been taken up by the Badische Anilin und Soda Fabrik is in the very best hands, and the recent award of the Liebig medal to the chemical engineer of the Badische Company, Dr. Schoenherr, is well deserved.

* * *

Meanwhile the erection of cyanamide factories is steadily progressing and the most important development in this line is the erection of a very large factory at Niagara Falls. The cyanamide process is not as direct as that of producing nitrogen oxides by electric discharges. The cyanamide process needs first separation of nitrogen from the air, for instance, by liquefying air and fractional distillation; the nitrogen is then combined with calcium carbide at an elevated temperature to form calcium cyanamide ("lime nitrogen") which may be used either directly as a fertilizer or as a starting point for making other chemicals like cyanide. The price which the cyanamide company is reported to pay for power is the lowest ever heard of at Niagara; Mr. Sperry, at the recent Electrochemical Society meeting, claimed it to be somewhat between \$10 or \$12 per horse-power-year, but certainly less than \$12. This would be very low in comparison with Niagara prices of the past but it is still much higher than the cost of some water powers in Norway, for instance. And it is very important to keep strictly in mind that all the processes for the fixation of atmospheric nitrogen can be successful only with cheap power, although the exact figures are known at present only by insiders.

The Drop in the Price of Aluminium.

As was already mentioned in our last issue, the price of aluminium has now dropped to an extent which reminds one of the slump in copper last year. The stage of the aluminium tragedy has been in Europe. In this country the Bradley internal heating patent decision of five years ago, which was against the Aluminum Company of America (at that time named the Pittsburgh Reduction Company), became a blessing in disguise for this company, since after having made arrangements with the owners of the Bradley patent, they were able to maintain their monopoly in this country under the protection of the Bradley patent, after the expiration, in 1906, of the fundamental Hall patents for the electrolyte. The Bradley patent will run out during 1909; until its expiration the Aluminum Company of America is protected as sole producer in this country. The situation has been different in Europe. Stability of production and prices has been maintained there in the past by a firm agreement between the different producers, the so-called international aluminium syndicate, formed in 1901. The objects were to establish distinct spheres of interest and stable prices. For a number of years the syndicate succeeded admirably. But, naturally, as a result of no further protection being obtained by patents in Europe, competition started. Several new works—some quite large ones—were erected by outsiders, and the fight began, with the natural consequences. A great factor in this fight was the decline of the demand for aluminium, especially by the automobile industry, on account of the financial and industrial crisis last year. The last result which we reported in our last issue was the dissolution of the syndicate agreement on Oct. 1, and the final slump in prices began. The price of ingots in London is now between £65 and £75 per ton, which is equivalent to 15 to 17 cents per pound. On

account of the protective duty, the price in this country is about 25 cents per pound. Though in this European war this country has been only an onlooker, the reaction has been distinctly felt here. The monopoly in this country had to yield, since imports from Europe threatened, and 25-cent aluminium means a great change, indeed, from the former steady price above 40 cents.

* * *

It is questionable whether the price will remain as low as it is at present. It seems quite certain that some of the European plants are now forced to sell aluminium below self-cost (if self-cost includes interest on capital, depreciation, etc.). The aluminium industry has always been carried on with greatest secrecy. Nevertheless, the cost of producing aluminium has been estimated to be something like 15 or 16 cents a pound, but the exact meaning of "cost" in these estimates is very doubtful. On the best authority which we have in a special case, the cost, including everything, figured out as only very slightly less than 16 cents per pound in a proposed French mountain plant (which was not erected, but was figured out with greatest care), the cost of electric power being in this case about \$8 per hp-year. This was under very favorable conditions of supply of raw materials and electric power. There is no such cheap electric power available for prospective aluminium makers in this country. As a matter of fact, the present situation in the aluminium industry is not very attractive for outsiders to start competition with the present sole producer after the expiration of the Bradley patent in 1909. We may expect fluctuations of the price of aluminium in the near future. The price may finally rise again, but it seems certain that it can never return to the old figures of two years ago. Aluminium appears to have come down for good to a price comparable with copper; there is very little difference now in the London price quotations for copper and aluminium. The net result will be the use of aluminium for many purposes to which it is very well suited, while the former high prices were prohibitive.

The Wear of Iron and Steel.

We have become so accustomed to regarding the great bulk of iron and steel in use as indestructible, except through chemical action, that it is somewhat startling to reflect that certain uses have become so important as to involve the mechanical disintegration and dissipation of an annual tonnage which reaches the dignity of six figures. A line of study is here presented which hitherto has been pursued but little, while prospective changes in materials used make it certain that it is going to receive careful thought in the future. It has been well known, of course, that a large part of the wear of railroad rails, necessitating their replacement, is due to actual disintegration and dissipation of the metal. In a rail worn so as to be unfit for further use there has been a change in the configuration of the head, due to flow of metal, while there has also been a loss of metal. The process of "renewing" rails which have become unfit for service has been more or less in vogue for years and consists in restoring the head of the rail to a proper shape. This process, however, has been treating but a limited tonnage in proportion to the total tonnage of rails annually rendered unfit for further service, and it is recognized by rail experts that a good rail should not be subject to much flow of metal in service, but rather should wear out merely by the dispersion and loss of metal.

This wear is due almost wholly to the rolling friction between wheel and rail. There is wear also of the wheel from this friction, and the quantitative relation between the two is largely a function of the relative hardness, which brings us to a very practical point. Steel wheels are being substituted for the regulation cast-iron wheel, and it is predicted that in course of time the substitution will be complete. It is obvious that the wear of the steel wheel will be altogether different from that of the cast-iron wheel. The steel wheel is made of steel of composition quite comparable to that of rail steel. While the carbon, and consequent hardness, may be a trifle greater than with rail steel, there is a wide gap between the wearing quality and that of the material in the tread of the cast-iron wheel, which is chilled cast iron, and extremely hard. Evidently the loss in weight of the steel wheel, per distance run, will be much greater in the case of the steel wheel than in the case of the cast-iron wheel. The car wheel wears in another way also than by reason of the rolling friction on the rail, on account of the frequent braking necessary to control trains. As between the cast-iron brake shoe and the chilled-iron tread, the wear is presumably almost altogether in the former, but what will be the relation between a cast-iron brake shoe and a steel wheel? Again, will the rolling friction of a steel wheel instead of a chill tread iron wheel on the rail increase or decrease the wear of the rail itself?

* * *

These are very interesting points, and a little indulgence in figures shows that the quantitative solution of the problem involved is of great economic importance, on account of the tonnages involved. Accurate data have not been gathered, but there is sufficient information available to make computations which, while not necessarily accurate, easily prove the magnitude of the tonnages involved. The wear of rails has not been accurately ascertained. Our total production of rails reached 3,977,887 gross tons in 1906, and has averaged fully 3,000,000 tons a year in the past 10 years. These statistics, however, are no guide, as rails are made for export, for mining, logging and other industrial purposes, for trolley lines, for laying new steam railroad track, to replace lighter sections on account of heavier traffic, and to make up for wear. No segregation has been attempted which would show the tonnage normally required for the last-named purpose. The closest approach can probably be made by seeking for statistics of a given operation. The Pennsylvania Railroad system gives annually its statistics of "steel rails used for renewals." The Pennsylvania system has probably progressed farther than any other in attaining a standard weight of rail in its tracks, so that its renewals may be taken as almost wholly due to wear. In the past four years it has averaged 138,085 tons of rails used for renewal, while its average freight-ton mileage has been 31,307,000,000 a year. Dividing the latter by the former, a factor of 226.720 ton-miles of freight per ton of rails worn out is found. Dividing the total freight ton-mileage of the United States in 1907, a record year, by this factor gives 1,028,300, this roughly approximating the number of tons of rails worn out by service in such a year of maximum tonnage. The finding is only roughly approximate, on account of many influences not necessary to discuss. If, now, a rail loses 15 per cent in weight in becoming unfit for further service, there is an actual loss of weight annually

of about 150,000 tons. Doubtless the loss is at any rate in excess of 100,000 tons in a year of full traffic, which material has been costing the railroads \$28 a ton, plus freight. There is a still greater loss, in that the remaining weight of the rail has been depreciated from \$28 to the price obtainable for old rails, this price having ranged this year within the limits of \$12 and \$18 a ton. These losses are due to rolling friction. Will the use of hard steel instead of chilled cast iron increase or decrease the loss, and how much?

* * *

The wheel problem itself is still more interesting. Using statistics merely as a rough index to the nature of the problem, it may be cited in the case of freight-car wheels only, that there were at last report (1907) 2,084,214 freight cars in the country, with a total freight ton-mileage movement of 233,137,507,807, which would probably mean about 16,000,000 miles traveled by the cars, loaded and empty. Multiplying this by eight, the number of wheels per car, and dividing by 70,000, the usual estimate of the mileage of a wheel which does not break, gives 1,830,000 as the number of freight-car wheels which would wear out in a full year of traffic. As the wheels average about 700 lb. apiece, the weight involved would be about 570,000 gross tons. The loss of metal in wearing out is reputed to be somewhat under 3 per cent, involving 17,000 to 18,000 tons annually. Wear on the rails is caused also by passenger cars and by locomotives and tenders. Passenger car-mileage is only about one-eighth of freight car mileage, so that over half the rail wear is doubtless due to the passage of freight cars, say, not far from 75,000 tons of rail steel worn off, against 15,000 or 17,000 tons of material worn off freight car wheels by the action of the rolling friction and the braking. Although expert testimony is lacking, it seems safe to assume that the great bulk of this wear is due to the braking, so that in the rolling friction nearly all the loss of metal is by the rail, very little being lost by the wheel.

* * *

What will be the wear of the steel wheel itself, and will the wear of the rail be altered by the change from the chilled cast-iron wheel to the steel wheel? There is some ground for presumption that the steel wheel will wear, from the rolling friction, almost as much as the rail, and if so, the loss of metal by the steel wheel will be much larger than the loss by the iron wheel. It will be a serious matter if it reaches 150,000 tons a year. For the steel wheel a much longer life is expected than is realized with the chilled cast-iron wheel, but that does not necessarily mean less loss of steel. The iron wheel wears very rapidly once the hardest part of the chill has worn off, whereas with the steel wheel the wear could easily reach a considerable depth. Some tests by the Pennsylvania, we understand, have promised a life for a steel wheel three times the usual life of an iron wheel, but doubtless the loss of metal would be much greater than with the iron wheel, as we have the testimony of an expert that the average cast-iron wheel, weighing when new, say, 700 lb., loses only about 25 lb of metal in service. Problems involving the dispersion and absolute loss of hundreds of thousands of tons of metal annually, and the rendering unfit for service of many times that tonnage of rails or wheels, will doubtless receive the careful attention of the experts in the field.

The Increase of Gold Production and the Increased Cost of Living.

Everyone is familiar—most people unpleasantly familiar—with the constantly growing cost of living in the past 10 years. Careful inspection of household accounts would place this increase at between 40 and 50 per cent, probably nearer the higher figure. The alleged causes of this are numerous—labor troubles, the increased national expenditures, general personal extravagance, the formation of "trusts" and monopolies, and so forth. These are really mostly only symptoms. One of the fundamental causes is undoubtedly the increase in the production of gold, although there are other contributing causes. In turn, the increase in the production of gold has been caused by the application of modern science to gold mining and metallurgy, resulting in important progress in the cyanide process, high explosives, the power-drill, and electrical transmission of power. In general, all industry and all our social life has been profoundly affected by the expansion of applied science. Both of these tenets, the minor as well as the major, have been often referred to in our editorial columns. In the lay journals, also, the same question is now receiving attention. Lately various expositions of the effect of "gold depreciation on prices and values" have been given by different writers in the popular magazines.

* * *

The official facts are that the world's production of what the journalists style, "the yellow metal," was, in round numbers, as follows: In 1884, 102 millions of dollars; in 1896, 202 millions of dollars; in 1907, 413 millions of dollars. At present, gold production, which was restricted in 1907 (only increasing a little over 1 per cent) by the increase in cost of labor and supplies, and also by the actual physical difficulties in procuring these, is now increasing more rapidly than ever and piling up so fast that the reserves of gold in Paris, New York, London, and Berlin are enormous, and the interest rates are now at the lowest figures in recent years. The natural inference from this is that since the interest rates had, early in 1907, risen so rapidly all over the world that the margin between interest paid by the "entrepreneur" and the profit arising from his usufruct of capital had been cut so low that the restriction in business was logical and, in fact, inevitable. For, of course, when business conditions were such that the business man could not make enough to pay the interest asked for money borrowed, the volume of business must recede. The converse of this is that when interest rates are so low that there is a wide margin or "difference of commercial potential" between what the capitalist asks for the use of his capital and what the business man can make out of this capital when lent him, that then the volume of business will increase. As in any system, be it electrical, physical or economic, there is a "lag" between "the impressed force" and the "flow of current," so the lag in the system under consideration is caused by the "commercial inertia." Just as in an electrical circuit, there is a measurable moment of time between the closing of the switch "putting 110 volts on the line" and the resultant flow of 110 amp through a resistance of 1 ohm, so is there an interval from the time when the "commercial voltage" is applied (represented by the marginal difference of 3 per cent between the average rate of in-

terest, say, 4 per cent asked, and the productivity of capital, say, 7 per cent), until the volume of business increases. The "lag" in the case of the electrical circuits is due to "self-induction," which may be illustrated by the model that the many little magnetic circuits or "idle wheels," as one physicist calls them, must be started, turning each other successively. So, also, the wheels of business of the many interdependent business circuits of "producer-consumer," "consumer-producer"—for each working individual produces or helps to produce one class of commodities and consumes those produced by other people—must slowly start each other in motion. This analogy between business and electricity is, as analogies go, a fairly close one.

* * *

With this country and Germany as leaders in this development, the world has had in the past seven years a prolonged period of inflation and expansion, followed by social and political unrest, increased cost of living and high interest rates. One writer makes the statement, with the vertigo of the prophet, that "our present troubles may be multiplied several times before the end of the next decade." This we believe to be a rather extravagant statement. To everything there is an opposing force. And against this can be said that in 1907 there was a perceptible check to the increase in the production of gold, due to labor troubles and enhanced cost of labor and decreased efficiency of labor. This was felt everywhere, in the Rand, in Colorado, in Nevada, and in Alaska. It was a real condition and not a theory. There are many good gold mines that because of this have not been paying propositions, if the depreciation of the mine due to the exhausting of its ore-body be reckoned. Next, other nations will find it profitable to change from a silver basis to a gold basis, and this will increase greatly the need for gold. Finally, the volume of the world business has been in the past so expanded that it needs a greater supply of gold for the increased volume of trading. This is an age of metals, and let us consider two metals most necessary for modern civilized life, namely, iron and copper. These metals resemble gold in one respect, that a large proportion of their production is not annihilated when passing into the consumer's hand, but form a permanent supply that returns to the market sooner or later in the form of "scrap." Taking the seven years of expansion from 1900 to 1906, inclusive, which are the fairest test years, we find as follows: The gold production increased from 1900 to 1906 from \$260,700,000 to \$407,700,100, or 147 millions, an increase of 56.5 per cent; copper production increased from 526,000 short tons in 1900 to 790,000 short tons in 1906, or 266,000 short tons, an increase of 48.4 per cent; pig iron increased from 28,700,000 long tons in 1900 to 49,900,000 long tons in 1906, or an increase of 73.9 per cent. Now, as the prices of these metals increased about 50 per cent in that period, we see that their aggregate value measured in terms of gold, increased much more than the increase in the money to buy them. This tendency of things to compensate each other shows that the effect of gold increase was to stimulate production of all things by an increase in price until both price and production outran the ability of the world to purchase things.

* * *

There is one other factor of great importance in effecting inflation. In examining into the past for the sake of learning

about the future, we see very clearly that the amount of "destructive consumption" was a cause of the period of inflation starting with 1899 and ending 1907. For, beginning with 1898, we had for eight years a series of events which caused the destruction of much capital and diminished by just such an amount the capital available for the constructive enterprises that modern civilization so sorely needs. These were our own little Spanish and Philippine imbroglíos, the great Anglo-Boer war, which caused such a strain on the "rich man of the world," England, the Russo-Japanese war, the San Francisco and Valparaiso earthquakes. The amount of destruction that these did was incalculable and their action was successive. Accordingly, they had a series of stimulating effects on business, as they made successive demands for the increased production of all commodities. Such a period of inflation was seen in 1867-72, and the long period of depression following this period was the reaction from the artificial stimulus by the destructive consumption of our civil war. The amount of much future "destructive consumption" cannot, of course, be foretold, for it is in its nature entirely fortuitous. Undoubtedly its influence on future inflation will be strong, and without wars or other calamities, our industry should have a more normal growth, although unfortunately we can surely count on much by the waste and extravagance of most of the American people, rich and poor alike. But even without the artificial stimulus of wars and earthquakes, the increase of gold production will act seductively by making the speculative part of the public rich, and some of the people think they are richer than they really are.

* * *

Such a discussion, if continued, would lead to more difficult questions of finance. But, in brief, it can be stated that gold production will increase in the future, but at varying rates of growth. The maximum will be reached shortly after periods of depression when the one commodity for which there is a certain market is gold and the cost of producing an ounce of gold in labor and supplies will be lessened because the supply of these is greater than the demand of post-panic times. At this time interest rates will fall to a minimum. The minimum of increase of gold production will follow a period of inflation when consumption of base metals and commodities is at a maximum, and the prices of these have arrived at a maximum, to such an extent that the volume of trade can only be extended beyond the limits of safe banking. At this time interest rates will rise to a maximum. Finally, a crash will come because the financially wise will have started to call in their loans if lenders, or not to make loans if borrowers, because the margin between rates of interest and productivity of capital is approaching zero as a limit. This is the cycle of prosperity and depression as indicated by the course of gold production and as affected by it. It is to be supposed that with the greater diffusion of intelligence and better facilities for transmission of information, as the ocean cables, telegraph and telephone, these industrial cycles will be shorter in period and less violent. This expectancy would be logical, but that socialistic agitation from the "many that have not, yet want" will tend to increase the severity of industrial depressions. And, after all, human nature is more or less immutable.

American Mining Congress.

The eleventh annual session of the American Mining Congress will be held in Pittsburgh, Pa., on Dec. 2, 3, 4 and 5.

"The American Mining Congress is a voluntary association of mining men, devoted to the up-building of the mining industry. In years past it has been largely devoted to the precious-metal mining interests, but the appalling and unnecessary loss of life in coal-mining operations has induced it to make an active effort looking to the adoption of such legislation as will furnish greater safeguards to the working miner.

"Congress, at its last session, appropriated \$150,000 to be used in investigations looking to the better protection of lives of miners. The success of this work was made possible by the active co-operation of the coal mining interests and indicated the apparent necessity of uniting every branch of the mining industry into an organization which would urge legislation of general benefit. The further efforts for the final enactment of House Bill 20,883, creating a Federal Bureau of Mines, and the securing of proper appropriations for its effective work, should receive the active co-operation of mining men everywhere."

Mr. J. H. Richards is the president. Mr. J. F. Callbreath, Jr., care Chamber of Commerce, Pittsburgh, Pa., is the secretary.

American Institute of Chemical Engineers.

A meeting of the American Institute of Chemical Engineers is to be held in Pittsburgh, December 28th and 29th, in the buildings of the Carnegie Technical Schools.

Papers of general chemical engineering interest are to be presented. Notable among these will be a paper of Mr. James Gayley, vice-president of the U. S. Steel Corporation, regarding his now celebrated process for dehydrating air, for the blast for blast furnaces, and for converters. Other papers on the use of fuels and the production of power are to be presented. "The measurement of high temperatures" and "dryer calculations and dryer designs" are the subjects of two other important papers.

One interesting feature of the Pittsburg meeting will be the exhibition by manufacturers of novel plants and machinery, partly by drawing and partly by the actual installation for tests in the presence of the Institute. These exhibitions and tests are in no way official in that the Institute does not undertake to pass official judgment upon any of the exhibits, and are no more sanctioned or indorsed by the Institute than technical papers presented to it would be, but are offered by the manufacturers as a method of acquainting those in charge of manufacturing operations with the latest and best machinery in the various lines.

Such an exhibit, however, should be an increasing source of breadth and education to the members, and the tests and discussions which will inevitably result from the special installation of machinery for this purpose should do much to unify the judgment of chemical engineers on the question of certain classes of apparatus which have hitherto been largely matters of individual opinions.

This meeting will be the first annual meeting of the American Institute of Chemical Engineers, organized last spring in Philadelphia for the purpose of bringing together all those who are particularly interested in the combined application of chemistry and engineering to technical problems. An account of the proceedings of this inaugural meeting was given on page 272 of our July issue.

The organizers of the Institute, after considerable investigation as to the need of such a society, have made the qualifications for active membership extremely rigid, believing that a very important object of an organization of chemists or engineers (besides meeting for purely social purposes) should be the raising of the professional standard among its members. To this end a careful and serious effort is being made to so

limit membership that admission to the Institute will be in itself an evidence of the standing and reliability (both business and professional) of its members.

That there was need for some such movement is sufficiently evident by the extent to which fake processes have at times been offered in this particular field. Hitherto chemistry has, by the very nature of the phenomena studied, the transformation of matter, presented that element of the mysterious which seems to be important to the successful exploitation of fraud. Numerous patents, which never worked and never could work, have been taken out and sold or made the basis of "wildcat companies." Numerous manufacturers have been victimized and it is hoped that in time the Institute of Chemical Engineers may be able to do for the chemical engineering profession what the Society of Civil Engineers has so ably accomplished in its field.

All communications from those desiring to attend the Pittsburgh meeting, or from manufacturers who desire to exhibit, should be addressed to the secretary, Dr. J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

American Electrochemical Society.

The annual meeting next spring will be held at Niagara Falls, Canada, on May 6, 7 and 8; the headquarters and place of meeting will be the Clifton House on the Canadian side.

President Acheson and the other Niagara Falls members of the Society have expressed their intention to make this meeting a record-breaking one as far as that is in their power. One day of the meeting will be devoted to a symposium on the electrometallurgy of iron and steel.

The increase of membership of the American Electrochemical Society has been most gratifying during the last few months. After 61 gentlemen, the names of whom were given in a recent issue, were elected members at the September meeting of the Board of Directors, 29 more members were elected at the October meeting.

The Iron and Steel Market.

There has been no change in the month in the general demand for finished steel products. In the second half of October a fairly heavy buying movement in pig iron started, and this continued for a short distance into November. A general advance in pig iron prices then took place following, chronologically, the buying movement, the election and the improvement in sentiment, but just what relation of cause and effect there was is not so easy to determine.

Last June marked a low point in demand for iron and steel products. Since then there has been a more or less irregular increase in demand. The increase has been at a less rapid rate in the later than in the earlier part of this period. The present outlook is that the demand, in point of tonnage, is likely to be less in the next three months than it has been of late. This does not reflect any less strength in the general market situation; it reflects rather the season, which is naturally one of light operation in many products, particularly the heavy tonnage lines such as rails, plates and shapes. Since last October the steel industry has been operating at much less than full capacity; for about three years previous it had operated substantially at full capacity. Then buyers had to take deliveries of material when they could get them and there was no slackening off in total tonnage in the winter months. Now, on the other hand, deliveries are subject to the convenience of the buyer.

Prices for steel products are more firmly held than for several months. In late September and early October there was a little shading in tin plates, but this quickly disappeared, and the market has since been firm. In black and galvanized sheets there was shading for months, but about the middle of Novem-

ber the market became firm through the determination of individual manufacturers that no advantage was to be gained by shading. In plates the shading has decreased.

Early in the month the rail mills reaffirmed existing rail prices for 1909 delivery, as was to have been expected. The Atlantic Coast Line placed an order for 25,000 tons; otherwise little has been done in rails. The railroads are not placing orders as early as usual, partly because they have no doubt that any desired deliveries can be secured with orders placed later and partly because they are not sure what their financial resources will permit them to do. This year's rail production will probably fall below 2,000,000 tons, against between 3,600,000 and 4,000,000 tons in each of the past two years. Demand will be larger for next year, as rails are wearing out, but it is the fact that much less than half the production in the past few years has been for the purpose of replacing rails merely because they were worn out.

Chairman Gary, of the United States Steel Corporation, has issued cards for another dinner to the iron and steel interests, Dec. 10, in New York. No matter of importance is to be discussed, while there will doubtless be much felicitation on the favorable outcome of the national election.

Pig Iron.

Following the general buying movement in the last fortnight of October, which was particularly heavy in New England and other Eastern districts, there was a fairly active market in early November, partly the closing of negotiations undertaken in October, but involving also heavy buying of basic pig in the East up to the middle of the month, and fairly heavy buying from furnaces along the lake front. Prices were pretty generally advanced toward the close of the movement, the advances being most conspicuous in the case of Mahoning and Shenango Valley furnaces, the advance in which district was quite out of line with actual conditions and seems to have been prompted almost wholly by sentimental considerations. While a large tonnage of pig iron has been bought, in the aggregate, it is important to note that deliveries extend over a long period and do not foreshadow any material increase in the daily rate of consumption. The buying seems to have been prompted almost wholly by a belief on the part of consumers that prices had got as low as they were likely to get, and might undergo some advance. There has been a rather large increase in production by merchant furnaces, and there is reason to believe that the increase in production has exceeded any increase, realized or in prospect, in the consumption. The output of steel works furnaces has been regulated more closely to the actual requirements.

Present asking prices of valley furnaces represent a rather wide range. A few furnaces appear willing to do \$15.50, furnace, or \$16.40, delivered Pittsburgh, on No. 2 foundry for first quarter delivery; others have a minimum of \$16, and others quote still higher. On basic iron prices range from \$15.50 to \$16, while on Bessemer there are a few sellers at about \$16, the largest producer quoting \$17. The low points, made in October, were \$14.35 for No. 2 foundry, \$13.85 for basic and \$14.45 for Bessemer. These prices were close to cost, in the case of a furnace buying its ore in the open market, and the question then was whether the market would remain in such relation, or would decline below that cost level, but leaving a profit to those furnace interests having their own ore supplies. Present asking prices involve an excellent profit, as, roughly speaking, a profit of a dollar a ton will pay for such furnaces as these in the course of from three to five years' production. The advance in the valleys had a direct effect on the Chicago market, withdrawing competition and allowing Chicago district furnaces to advance prices to a basis of \$17, Chicago, for No. 2 foundry. Eastern Pennsylvania furnaces have advanced prices slightly, to \$17 to \$17.50, delivered, for No. 2X foundry. The South is firm at \$13, Birmingham, for any delivery, an advance of 50 cents.

Billets and Sheet Bars.

The market has been very quiet in rolling billets, but there has been a decided improvement in demand for forging billets, especially in the West. Sheet bar requirements are heavier. Prices remain at \$25, Pittsburgh, for rolling billets; \$27 for forging billets and \$27.50 for sheet bars, half the freight from Pittsburgh being conceded when the rate lies between \$1 and \$3.

Finished Material.

As noted, the concessions on certain lines have almost entirely disappeared. There is not a great deal of new buying, but with some new buying and with specifications on old contracts the volume of finished steel business coming to the mills is about up to the average of the past two or three months. Tin plates have taken on more activity, being bought with confidence for first quarter delivery, the chief activity being in plates for the salmon packing trade.

Prices are substantially firm, as follows, except that light rails are sometimes shaded about \$2 a ton. Prices are f.o.b., Pittsburgh, except in the case of standard rails, which are f.o.b. mill.

Standard rails, \$28 for Bessemer, \$30 for open-hearth.

Light rails, \$25.

Plates, 1.60 cents for tank quality.

Shapes, 1.60 cents for beams and channels, 15-in. and under, angles and tees.

Steel bars, 1.40 cents; iron bars, 1.50 cents, delivered Pittsburgh; 1.42 cents f.o.b. Pittsburgh for western delivery.

Plain wire, 1.80 cents; wire nails, \$1.95.

Sheets, 2.45 cents, net, for black; 3.50 cents, net, for galvanized, 28 gage.

Tin plates, \$3.65, net, for 100-lb. cokes.

Convention of the American Peat Society.

From an educational standpoint as well as an impulse for further advancement in peat utilization the Toledo meeting of the American Peat Society, on Oct. 22, 23 and 24, 1908, was a decided success.

Among the leaders in this new movement, to create a peat industry, are Prof. Charles A. Davis, author of the standard work on peat, chief in charge of peat investigation for the United States Geological Survey; Prof. R. K. Fernald, engineer in charge of gas producers, United States Geological Survey; Dr. Joseph Hyde Pratt, State geologist of North Carolina; Erik Nystrom, of the Bureau of Mines, Ottawa, Can., author of "Peat and Lignite," indispensable as a reference book on peat; Dr. Otto Zwingerberger; Robert Schoor, of San Francisco; Prof. Richter, of the University of Wisconsin, together with such serious and energetic field workers as Carl Kleinstueck, Dr. J. McWilliam, F. J. Bulask, Ernest V. Moore, the Milne Brothers, E. C. McKenny, Otis E. Moulton and many others.

In the absence of the president, Dr. J. H. Pratt, Prof. Charles A. Davis, of Ann Arbor, Mich., called the meeting to order on Thursday, Oct. 22. After a few preliminary remarks he introduced Mayor Brand Whitlock, of Toledo, who welcomed the delegates. Mr. Otis E. Moulton, of New Hampshire, then reported for the New England States. He gave a vivid description of various attempts made in Maine, New Hampshire and Massachusetts, and is convinced that quite a peat industry will spring up there during the next season.

Mr. Carl Kleinstueck, of Kalamazoo, Mich., reported for the Northwestern States. He had received numerous inquiries, and visited Mason City, Iowa, where he was called upon to pass judgment upon some excellent peat bogs found there. The outcome was the establishment of a plant at Fertile, Iowa, successfully operating all summer. His own plant was working at its full capacity, and he could have sold three times as much as he produced at \$5 per ton.

Mr. Erik Nystrom, of the Canadian Bureau of Mines, gave a brief report, stating that he only knew of two places where they are actually making peat-fuel in Canada. Many companies

have been formed, but nothing further has been heard from them. The government has been interested in the matter of peat development, and some surveys of different peat bogs have been made by the Bureau of Mines, which will establish a peat gas and power plant for experimental purposes during the coming year.

Dr. J. McWilliam, vice-president for Canada, then reported on the work done in the Canadian district, emphasizing the development of a process for making peat briquettes, and his experiments in using peat dust for fuel under boilers, which he had successfully accomplished with peat dried to 5 per cent of moisture.

Mr. F. J. Bulask, of Toledo, spoke on the work in the vicinity of Toledo. His peat-fuel plant has been hampered in its development because of lack of transportation facilities; but the delay has given time for experimental work in various directions. He emphasized the great need for a practical dryer for artificially drying peat fuel.

The election of officers resulted in Dr. J. H. Pratt being elected president. Prof. Charles A. Davis is editor-in-chief of the journal of the society.

The committee on resolutions and by-laws, consisting of Dr. McWilliam, of Canada, Mr. C. M. Crouse, of Syracuse, and Mr. C. T. Pennock, of Chittenango, N. Y., recommended that the membership fee in the future should be \$3 per annum, which entitles to all publications of the society, and that associate membership at \$2 per annum be discontinued. This motion was carried.

The papers read at the meeting, and which will be published in full in the *Journal of the American Peat Society*, were as follows:

"Commercial Aspect of Gasifying Peat," by Robert Schorr, engineer, San Francisco.

"Utilization of Peat," by Dr. Samuel S. Jodidi, Agricultural Experiment Station, East Lansing, Mich.

"Peat and Swamp Land," by Joseph Hyde Pratt, president American Peat Society.

"Life in a Michigan Peat Marsh," by Carl Kleinstueck, Kalamazoo, Mich.

"Peat in Ireland," by Herbert Garnett, Eaton Rapids, Mich.

"Briquetting of Peat," by Otis E. Moulton, Dover, N. H.

"Latest Developments in Peat Gas Producers," by Dr. Otto Zwingenberger, New York.

"Peat in Indiana," by A. E. Taylor, Findlay, Ohio.

"Artificial Wood Made From Peat," by F. Schuenemann, St. Louis, Mo.

"Latest Peat Researches of the United States Geological Survey," by Prof. Charles A. Davis, Ann Arbor, Mich.

All the papers were listened to with profound interest and interesting discussions took place, especially on peat drying, peat gas and the recovery of nitrogen for fertilizer. The majority of papers were on peat gasifying, and as both the United States Geological Survey at the Fuel Testing Plant, at Pittsburgh, Pa., and the Bureau of Mines, at Ottawa, Can., will install peat power gas plants, it is anticipated that in the New England States, in Michigan, Illinois and Western New York peat producer-gas plants will soon be erected. Prof. R. K. Fernald, engineer in charge of Gas Producer Division, United States Geological Survey fuel testing plant, gave a vivid description of a Swedish producer, successfully operated for two years, and Erik Nystrom, of the Bureau of Mines, Ottawa, Can., spoke of the Koerting gas-producer plant now in erection.

The Commercial Artificial Fuel Company extended an invitation to a dinner at the Hot4 Secor on Friday night, which was greatly enjoyed, and on Saturday the same company invited the guests to inspect their plant, 18 miles from Toledo. A full description of the workings of the plant will later be published in the *Journal*. The next meeting will be held in September, 1909, in Boston. Applications for membership are to be sent to the secretary-treasurer, Mr. Julius Bordollo, Kingsbridge, New York City.

CORRESPONDENCE.

The Origins of Hot Galvanizing.

To the Editor of Electrochemical and Metallurgical Industry:

SIR: It is generally understood that Craufurd's patent of 1839 marks the advent of Hot Galvanizing. This statement is copied from one article to another, but I have had the curiosity to look further back in the annals of science, as it seems inconceivable to me that earlier metallurgists should not have attempted the operation for commercial purposes.

The earliest record I have found is that of a certain Dr. Malouin whose researches were presented before the Academy of France in the years 1742 and following; his early experiments were made in 1741. Dr. Malouin published the fact that iron could be whitened by immersing in a bath of molten zinc, as in the case of tin. He claimed greater durability than in the case of tin-plate, and resistance to melting of the surface under great heat. We know that the greater durability is due to the direction of the electrolytic current set up by the metals in contact, and that galvanizing cannot be as readily sweated off iron as tin, because it is hardened and its melting point is considerably raised by absorption of iron.

In 1742 Jean Baptiste Kemerlin proposed various baths containing zinc for use on domestic utensils. Hot tinning had been introduced on a large scale long before this for coating copper and even iron plates and dishes which took the place of the solid tin ones, these being too expensive for the poorer classes to use. It was not, however, until the year 1778 that Monsieur de la Folie of Rouen suggested that instead of tinned copper, zinc iron be used for plates and similar articles. The deleterious effects of the zinc salts generated by the action of acids does not seem to have been known at that time, but it was noticed that the zinc was more readily attacked by various agencies when spread over iron than when by itself; this is due, as we know, to the electrolytic action which hastens the formation of zinc carbonate in the presence of moisture. In an extensive discussion of galvanized articles for domestic purposes which is found in the *Annales de Chimie* for the year XII (1803) vol. 51, page 49, the deleterious effects of zinc salts were thoroughly discussed and zinc finally condemned for the purpose.

One of the greatest drawbacks of galvanizing had been the difficulty of getting zinc to adhere properly to the articles coated. Resin, which was used in a powdered form as a tin-plating flux, had been tried for zincing also, but in the year 1802 Buschlaendorf, of Leipsick, proposed (See *Journal des Arts et Manufactures* for that year) sal-ammoniac to be used in place of the "colofane," or resin. He also suggested as the best method to follow in the case of copper articles, a first bath of tin and a second one containing two parts of tin to three of zinc.

Thus it is evident that galvanizing by means of a zinc bath, using sal-ammoniac as a flux, was known a considerable time before the appearance of the Craufurd patent.

PITTSBURG, PA.

ALFRED SANG.

The Inventor of the Tungsten Lamp.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—A great deal has been written and said about the tungsten filament and the Germans have received the credit of being its inventors. This, however, is not the case, although we must give them credit for its development. It has not been generally known that a young American, while still in his teens, was the inventor: Mr. Turner D. Bottome, who, by the way, was an exceedingly bright electrochemist and contributed a number of electrochemical inventions to the world. The writer was fortunate in knowing Mr. Bottome personally, assisting him in

some of his work and subsequently succeeding him, after he left the laboratory of Mr. Tibbits, through failure of health.

In the early part of the year 1887, Mr. Bottome, scarcely eighteen years old, became associated with a lamp company in Harrison, N. J., called the Vitrite Aluminoid Lamp Co. Being a great student and observing the defects of the filament, made by the company with which he was connected, he conceived the idea that the metal tungsten had properties of peculiar advantage for an incandescent-lamp filament, a metal of fairly high resistance, and of very high fusing point. During the process of the invention some men made strong efforts to get the invention away from him, and Mr. Bottome would have lost it but through the effort of the late John B. Tibbits, of Hoosick, N. Y.

Mr. Bottome told the writer the whole story and said that Mr. Tibbits came to his aid and after the patent was allowed he was paid a handsome sum for it. Mr. Bottome's application was filed September 29, 1887, and allowed April 9, 1889; it is No. 401,120. He also took out a patent for treating the filament, dated August 6, 1889, No. 408,286. Another patent of his relates to a molybdenum filament; the date of this I have not just at hand, but it was about the same time.

Mr. John B. Tibbits, who took up this young man, was an Episcopal clergyman of considerable means, and a man of very bright ideas and quite an inventor himself. He spent a large sum of money on electrical research work. This appeared to be a hobby of his, and he took great comfort in his work. Some of his suggestions were thought visionary at the time, but some of them have since been proven perfectly feasible.

In conclusion I would say that the credit of the invention of the tungsten lamp belongs to Turner D. Bottome, an American, and its birthplace is Harrison, N. J., the town of the largest lamp factory in the world.

SOUTH ORANGE, N. J.

JNO. A. YUNCK.

The Electric Furnace for Rail and Ordnance Steel.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—I have read with great interest Mr. Walter Rosenhain's paper on "The Study of Breakages," at the meeting of the British Association in Dublin, as published in your November issue, page 459. The subject involved is a very interesting one, as it covers a large variety of steel products, like rails, gun tubes and other ordnance materials, railway axles and tires, boiler plates, boiler tubes, steel forgings and castings of every description.

The sudden breakage of any of such products, while in service, is often accompanied by serious losses of life and limb and great loss of property.

I will only quote from Mr. Rosenhain's paper briefly such as comes within the scope of what I desire to say on the subject:

"According to the stage at which the defect which has resulted in breakage has arisen, the causes of failure may be classed into three large groups:

"Group 1.—Defects arising from the manufacture of the material of construction.

"Group 2.—Defects arising from incorrect treatment of the material during the process of construction.

"Group 3.—Defects arising during the life of the structure or machine."

The defects due to Group 1 and the defects and resulting accidents due to Group 3 are beyond any doubt the most frequent.

Ever since the railroads have found ways and means to definitely determine the causes of rail breakages, it has been proven that many of them were due to the presence of foreign, injurious bodies, such as slag, manganese sulphides, etc.

Later on it is stated:

"The paper concludes with four typical examples of failures with details of their investigation. The first, one of the inner

tubes of a large gun, which developed internal cracks and ultimately fissured completely after an abnormally short life. Tensile tests, alternating stress tests, and impact tests were made, as also detailed micrographic examinations, and the following summarized general conclusions deduced:

"The microscopic evidence, when correlated with the results of the mechanical tests, leads to the conclusion that as regards general composition, heat treatment and mechanical treatment, the steel of the fractured gun-tube is normal, but that its strength is perceptibly impaired by the presence in its mass of a very large number of slag enclosures. The presence of these foreign bodies particularly reduces the power of the steel to resist cracking transversely to the direction of forging, and the presence of longitudinal cracks in the tube is in accordance with this view."

At the meeting of the American Society for Testing Materials, at Atlantic City, held last June, Dr. Henry Fay, of the Massachusetts Institute of Technology, read an elaborate paper on "A Microscopic Investigation of Broken Steel Rails: Manganese Sulphide as a Source of Danger."

"The first piece examined was a small section broken out of the foot of a rail and having a good-sized check. The metal was cut through just beyond the check and polished to a mirror surface. The surface was pitted badly on a line with the check, and under the microscope manganese sulphide was shown where the pitting had taken place. The appearance of pitting from slag is usually quite different. Examinations were then made of a number of rails which had broken in the foot in the crescent form. Near the top surface of the fractured piece the metal in nearly every case showed a thin layer of more brittle material, and in many cases fine checks extending in the direction of rolling. In each polished specimen manganese sulphide was found in considerable quantities, either alone or accompanied by ferrite. Tests were made demonstrating the brittleness of the manganese sulphide, also that it was cemented but weakly to the steel in which it was embedded. Other fractures besides crescent breaks were also found to be connected with manganese sulphide. The form in which the sulphide exists determines whether it is harmful. If the metal has been forged the sulphide will appear in small spherical masses. If there has been rolling, begun at high temperatures, the sulphide areas will be elongated, as in the crescent breaks.

"Le Chatelier has stated that as sulphide of manganese often appears crystallized it has a higher freezing point than any other of the constituents. This has been granted by some experimenters and questioned by others. The author detailed an experiment by which he had determined the freezing point of manganese sulphide to be 1162°, refuting Le Chatelier's claim, and explaining the elongated masses of the sulphide. If rolling begins at any temperature above 1162°, the manganese sulphide will still be liquid from the temperature at which rolling began down to 1162°, and below this temperature being in a plastic condition it is elongated in the direction of rolling. It appears in elongated threads where rolling pressure is exerted on three sides."

Dr. Fay finally winds up as follows:

"Specifications should be so drawn as to limit the amount of sulphur in the steel. Then the metal should be allowed to stand longer after the ferro-manganese addition. With specific gravity of manganese sulphide 3.966 and of steel 6.82, the former should rise to the surface and be skimmed off with the slag if given sufficient time. Usually the interval between the ferro addition and pouring is very short. But if a low sulphur ore is not available to start with, or if a sufficient time cannot be given for the removal of manganese sulphide, a resort must be had to electric refining of the molten metal by means of a basic slag."

All the foregoing practically confirms the many reports made from thorough investigations of broken rails, both here and abroad, due to the same causes.

At the same meeting Col. E. D. Meier, Chairman of Com-

mittee R, urged for a purer, stronger and more uniform material for boiler plates.

It is stated that steel under 0.03 sulphur is hard to secure in view of the difficulties the steel makers are encountering with the raw materials and fuel obtainable.

People who are thoroughly familiar with prevailing conditions know very well that Dr. Henry Fay's call for purer ore and more time for removal of manganese sulphide and the demand of resting the hot metal sufficiently long after melting, to allow all the slag and other undesirable elements to rise to the surface and to be skimmed off, is in vain.

Such pure ores as he has in his mind are nowadays not obtainable in sufficiently large quantities to satisfy the enormous demands required for the large tonnage products, and the price of such high-grade ore would be prohibitive. At any rate, it is not to be obtained in any such quantities at any price.

Furthermore, our modern methods of producing an enormous tonnage within a limited time in oxidizing furnaces, considering space, facilities and labor available, exclude any such practice as suggested by Dr. Fay.

The plants, methods, facilities and help to handle the hot metal, the teeming and continuous and rapid progress of the whole process, to carry it within a limited space of time from the blast furnace to the finished product and get it out of the way as quickly as possible, does not admit of such a radical change. It would necessitate entirely new and much more costly plants, resulting in comparatively smaller product at a very much enhanced cost of production per ton.

Even if it were possible to make such a radical change, the desired result could not be obtained with present practice.

It is impossible to deoxidize the metal with methods available, or rather with the present practice in connection with oxidizing furnaces so thoroughly, as to remove all oxides of silicon and manganese formed as a result of the operation.

Even if pure pig iron was used, one would have to deal with more or less oxide gases and slag that could not be effectively and entirely eliminated. If I had the choice of steel rails, made from low-phosphorus and sulphur pig, finished in basic open-hearth furnaces, producing steel under 0.04 phosphorus and sulphur, I would prefer steel rails exceeding the above limit, provided the hot metal from the basic furnace had been finished and sufficiently rested in the electric furnace.

The little pockets containing these undesirable bodies in the finished steel are invisible in the rail, in the gun-tube or in any other product made from the metal. Some of them, and possibly the most pronounced ones near the surface, may be discovered at some stage during the process before or after reaching the finished stage, or by a destructive test. But it is not possible to apply such a test to every rail-bar or article produced, as only one can be destroyed out of a great many, and the one destroyed would prove nothing as regards the balance of the product.

As a chain is no stronger than its weakest link, any rail or beam or gun or boiler-tube, etc., is no stronger than the weakest spot that may be invisible to the eye and impossible to detect until through strain in service it suddenly gives away.

It is not my desire to repeat what I have pointed out repeatedly before in this journal and elsewhere, that it is not alone possible to overcome all these objections with the Héroult electric steel furnace, but the rapid increase of furnaces of this type already in continuous operation and under construction, subject to everybody's investigations, is proving this beyond doubt.

With modern power producing plants, hot metal from oxidizing furnaces can be purified and deoxidized in a Héroult electric furnace in a short time, producing a very pure material, free from slag and other injurious bodies; in fact, a material equal to best crucible steel, only more uniform, at a reasonable extra cost over open-hearth steel.

Owing to the very much higher value of crucible steel (more

than three times the value of ordinary open hearth) it is, of course, not practical to purchase steel rails or similar large-tonnage products of material made by the crucible process.

Since the Héroult electric furnace, however, has been brought to the present high state of perfection and rail steel and other large tonnage products can be purified and refined at moderate extra cost over cheap raw materials, there is no good reason why a superior product could not be put on the market and sold with a reasonable advance over Bessemer and open-hearth steel. All this can be accomplished simply by adding Héroult electric furnaces to already existing Bessemer and open-hearth steel plants without any radical changes whatsoever.

The railroads as well as all other consumers of steel are constantly clamoring for better and more uniform products. If steel rails can be furnished of superior quality, giving better and longer service, reducing railway accidents, due to rail breakages, it would mean economy for the railroads and protection to human life.

The proportionate extra value of such steel rails can be established.

The Government should be the very first, along with the railroad companies, to take advantage in securing a superior and more uniform ordnance material, as most of the same, now supplied for guns and other war materials, is being made in oxidizing furnaces, principally open hearth.

If the Government specifications of war materials would call, in future, either for crucible steel or steel made in oxidizing furnaces, purified and refined in electric furnaces, to be equal to crucible steel, I am sure a better, more uniform and more serviceable material would be supplied at a reasonable advance over open hearth.

If the railroad companies would give notice that they are prepared to receive bids for steel rails, finished in electric furnaces, specifying low percentage of phosphorus and sulphur and free from slag, manganese-sulphide, etc., they would soon be able to obtain rails of much better and more uniform quality, giving much longer service and a corresponding decrease of accidents due to rail-breakages. The advance over present price of rails would not be unreasonable and would figure out a saving in comparison with the price of the present standard article.

This is an age of progress. The next ten years will witness an enormous increase in speed of railway traffic. Space will be annihilated. Our leading roads are busily engaged electrifying their lines within a considerable radius of the large cities, and this tendency will grow steadily. The Pennsylvania Railroad announces its intention of electrifying the distance between New York and Philadelphia, practically doubling the present speed. With such an enormous increase of velocity the resistance to wear and tear and the purity of the metal must be increased in proportion. This applies to the rails as well as to the rolling stock, axles, wheels, tires, etc. It does not alone involve the question of economy, but what is of even greater importance, the safety of human life. There is no doubt that the leaders of our great railway systems and steel interests are realizing that there is but one way of solving the problem; namely, by raising the present standard of rails and other railway materials.

Over 20 Héroult steel furnaces are now finished and under construction, of which more than half are actually in continuous operation, producing thousands of tons of high-grade steel and in many cases the finest quality of tool-steel, cutlery-steel, etc., from the very same raw material and the same oxidizing furnaces of which the steel rails of this country are being made. All that is necessary to do is to pass the hot metal through the Héroult electric furnace and instead of the present much abused article, steel rails of tool-steel quality will be obtained. Steel-makers, railroad officials, and all who are interested, are cordially invited to see it done.

NEW YORK CITY.

R. H. WOLFF.

New York Meeting of the American Electrochemical Society

In the first years of its existence, the American Electrochemical Society used to hold two meetings a year, one in Spring and one in Autumn, in different cities of the country. This was considered too much of a burden, and there were many suggestions to drop one meeting altogether and to hold only the meeting in Spring. A compromise plan was then adopted, according to which the general annual meeting was to be held in Spring at places changing from year to year and a second smaller meeting in Autumn in New York City, as it was thought that many members would visit New York anyway about this time of the year and could then arrange to attend the meeting.

It was doubtful at first whether a second meeting of secondary importance would be attractive enough to make it worth while; and the relative lack of success at the first trial, two years ago, made it even more doubtful. But the situation changed very remarkably last year, and after the renewed and really fine success, achieved at this year's meeting on October 30 and 31, the Autumn meeting in New York has probably now become a permanent institution.

Like all meetings of the American Electrochemical Society it was a meeting "bristling with good fellowship." The at-

and guests were entertained by the staff of the Department of Chemistry at luncheon and later enjoyed an organ recital by Prof. S. A. Baldwin, head of the Department of Music, in the auditorium in the Main Building.

The session of Saturday morning was held in the lecture hall of the Chemists' Club. During the afternoon of Saturday an excursion was made to the Balbach Smelting and Refining Works in Newark, N. J., where the processes of smelting and refining of copper, lead, silver and gold were shown in operation. This was the third visit of the Society to one of the large electrolytic copper refineries near New York, the copper refining plants of the American Smelting and Refining Company and of the United States Metals Refining Company having been visited in previous years. Like these two, the Balbach works are operated on the multiple system of cells. (A full illustrated description of the Balbach refinery was given in our Vol. II, page 303. Concerning the Balbach process of parting silver and gold see also our Vol. III, page 374.)

The visit to the Balbach works was of especial interest since this is the first electrolytic copper refinery in the United States, having started operation 25 years ago. It was a great pleasure to the members of the Society to shake hands with the pioneer



PHOTOGRAPH TAKEN BEFORE THE CHEMISTRY BUILDING OF THE COLLEGE OF THE CITY OF NEW YORK.

tendance was beyond 200; an alphabetical list of those printed on the last registry list will be found at the end of this report.

A great deal of the success was due to the endeavors of the cordial hosts of the Society—on the first day, the College of the City of New York and the staff of its Department of Chemistry, with Dr. Chas. A. Baskerville as its head; on the second day the Chemists' Club of New York City, which lives up to its fine programme of endeavoring to become the professional home of all the chemists of the United States.

The two sessions of Friday, October 30, were held in the Doremus laboratory of the Department of Chemistry of the College of the City of New York. During the morning session President John H. Finley of the College welcomed the Society in a felicitous little speech, comparing in a very clever and humorous way chemical training of days gone by and of to-day. In the afternoon Dr. Baskerville sketched the engineering features and the organization of the Chemistry Building of the College of the City of New York. We intend to give an illustrated description of the Chemistry Building of the College in one of our next issues.

During the noon recess between the two sessions the members

of American copper refining, Mr. Edward Balbach, Jr. The visitors were taken through the works in numerous small parties, led by officials and engineers of the company, who proved excellent guides.

Of the purely social features of the meeting we mention the informal and highly enjoyable smoker tendered to the Society by the Chemists' Club on Saturday evening, and the subscription dinner on Friday night at Reisenweber's in which more than 700 participated. From the several after-dinner speeches we quote the following of President E. G. Acheson:

E. G. ACHESON ON THE AGE OF ELECTROCHEMISTRY.

"I think this an opportune moment to invite your attention to a subject that should be of interest to all of us.

"A young man wishing to devote himself to an established electrical industry would, twenty-eight years ago, have had to make a choice between electroplating, telegraphy, medical battery manufacturing, or the then recently established telephony. In the public press at that time appeared the first flashes from the incandescent electric light and the distant rumbling of electric traction. Our profession was then represented by electroplating, and it was not until 1888 that electrochemistry took its

first decided steps to attain its proper place among the industries of first magnitude. A very great deal has been accomplished during the years since that date—the annual production of electrochemical products now amounting to many millions of dollars—and I think we can confidently look for greater results in the near future.

"A great national movement was recently started to conserve our national resources, and no one should take a more prominent place in the proposed work than the electrochemist. Following the hydraulic and electrical engineers, the electrochemist should, by means of the electrical energy resulting from the utilization of our water powers, transform many of the chemical and metallurgical industries, as they now exist, into electrochemical and electrometallurgical ones, and he should greatly extend the list of products now used in the industrial world.

"Mr. James J. Hill, in his address at the Governors' Conference called by President Roosevelt last Spring, stated that, 'Fifty years ago the annual per capita production of coal was a little more than one-fourth of a ton. It is now five tons.' It will be largely through the work of the electrochemist that this rapid consumption of our coal supplies will be arrested.

"While reading Circular 157, issued by the Forest Service of the United States Department of Agriculture, I was caused to liken the consumption and destruction of our natural resources by the present generation to the waste and devastation left in the path of a swarm of locusts, and surely, if this destruction be continued, posterity will severely criticise us. Mr. H. St. Clair Putnam, in an address at the Conference of Governors stated, 'The full development of all the water possibilities of the country would, according to expert estimates, furnish a power equalling and probably greatly exceeding five times the present total horse-power of all kinds, or 150 million horse-power.' We cannot fail of being impressed with the immensity of the field for operations of the hydraulic and electrical engineers and the electrochemists in the harnessing and utilization of this tremendous power, and through its proper utilization the present wasteful consumption of our natural fuels should cease.

"It should not only do our transportation and manufacturing, but, as, formerly stated, greatly add to the number of our manufactured products, placing as it does in our hands the attainment of the highest possible earthly temperatures for the breaking up of the old and the forming of new chemical combinations, thus, through the electrochemist, mastering the fixation of the nitrogen of the air we will have the means of insuring the continued fertility of the earth to meet the requirements of posterity. Even now the world is under obligations to us in a measure not generally realized. Thus, the great glare of light that lights the automobile on its flight was made commercially possible by electrochemistry.

"In Circular 157 I have mentioned, the author states: 'This is the beginning, the engineers tell us, of the age of electricity and that means the beginning of the age of water-power,' and to this should be added, 'and that means the beginning of the age of electrochemistry.' What a great age it will be! We, the men of to-day, are just breaking the ground. To our children we will bequeath a valuable heritage, and the proper preparation of the succeeding generations for the successful furthering of this work largely devolves upon the ladies—the mothers—their influence on youth far transcending that of the fathers. Can we justly estimate their beneficial influence upon the men of their own generation?

"I remember having once seen an old print in which was portrayed a scene in Michael Faraday's laboratory. The time was late in the night. Faraday had just produced an electric current by induction, and on breaking the circuit obtained a bright spark. So thoroughly did he appreciate his discovery and so happy was he over the achievement, he at once went and aroused his wife that she might share in the pleasures of his triumph. It is conceivable that Mrs. Faraday would have preferred to continue her slumbers, but can we know to

what extent her apparent interest influenced her husband in continuing his classical researches that made possible practically all of the present electric age, and the electrochemical age now dawning."

In the following we give abstracts of all the papers presented at the meeting. The papers presented at the Friday morning session related to various subjects of scientific interest.

Mercury Cathode for Electro-Analysis.

The first paper presented related to the use of a mercury cathode in the determination of metals, the authors being A. HAROLD PORTER and FRANCIS C. FRARY, of the University of Minnesota. In the absence of the authors the paper was presented in abstract by Prof. J. W. Richards.

The chief results are as follows: The electrolytic determination of zinc in a mercury cathode gives low results, due to loss of both zinc and mercury in the process of washing with alcohol and ether. Pure mercury does not lose weight appreciably when washed with water, alcohol and ether, nor by liberation of hydrogen on its surface even at high temperatures (100°). The loss in weight during washing seems to be peculiar to zinc, since copper amalgam shows no signs of it, and the determination of copper by means of the mercury cathode is quite satisfactory.

Determination of Zinc.

Following the paper by Porter and Frary, Prof. Walter T. Taggart, of the University of Pennsylvania, read a paper by Miss LILY G. KOLLOCK and Dr. EDGAR F. SMITH on the determination of zinc with a mercury cathode and a rotating anode.

The authors give details to be observed in order to insure complete precipitation of zinc. The cup must be clean; use 50 to 60 grams of pure mercury; keep cup covered with watch glasses; electrolyze the solution of zinc sulphate diluted to about 10 cc with current of 1 to 3 amp and 8.5 to 5 volts for 12 to 15 minutes; rotate anode 550 to 750 times per minute. When the decomposition is completed the motor is stopped, the cover glasses removed, and distilled water poured into the cup from the wash bottle and the liquid siphoned out until the level almost reaches the spiral portion of the anode. The cup is then refilled with distilled water and the operation repeated until the current falls to zero—300 c. e. of water being used for the purpose. The acid liquid must be removed before the current is broken. Pour off the water remaining and wash quickly three times with absolute alcohol and two or three times with absolute ether; place in desiccator and finally weigh.

Thirty-seven determinations of a solution containing 0.1316 gram zinc gave an average of 0.13155 gram zinc. No zinc or mercury was found in the water, alcohol or ether washing.

In discussing the paper of Porter and Frary, Dr. Patten emphasized that the area of the mercury cathode used should be given, with exact dates on voltage, current and current density. The papers were also briefly discussed by Dr. J. W. Richards.

Passivity of Iron and Nickel.

A paper by Prof. E. P. SCHOCH, on the passivity of iron and nickel, was presented in abstract by Dr. Patten. The author first sketched various theories of the passive state—the oxide film theory of Faraday; the valence theory of Krueger, Finkelshtine and Mueller, which finds the cause of passivity within the metal itself; and the various reaction-velocity theories, of which Le Blanc has given the general formulation, while the special formulation of Fredenhagen and of Muthmann and Frauenberger emphasizes the slow velocity of reaction between oxygen and metal, so that oxygen accumulates, and a lower potential is obtained. Sackur, on the other hand, has emphasized the slow reaction between oxygen and hydrogen within the metal.

Experimentally the problem of the passive state may be attacked by either of the following methods: (1) Relation of current density to polarization at anode in various electrolytes;

(2) measurement of capacity (electrostatic); (3) optical properties of the anode surface with reference to film formation; (4) effect of alternating-current electrolysis; (5) catalytic influence of the metal upon the union of hydrogen and oxygen; (6) conditions under which a metallic oxide is formed at the anode; (7) effect of mixed electrolytes, as in Luckov's phenomenon.

(1) In the main metals are more readily made passive in alkali solutions, but iron and nickel and many others may be rendered passive in acid solution. The critical current density at which a metal becomes passive increases in general with the concentration and with the temperature. But at high concentrations or at high temperatures the passive state is sometimes not attained.

(2) The condenser effect at the anode may be measured and the leakage current through the film may be determined. But Dr. Schoch says that the presence of a condenser effect does not necessarily require a film on the anode, since an oxygen layer would give the same effect.

(3) Optical determinations decide nothing according to Dr. Schoch.

(4) As to the effect of alternating-current electrolysis, Ruer has recently found that platinum dissolves when subjected to alternating current in an electrolyte. His idea is that by anodic reaction a platinum oxide is formed. But on reversing the current, the oxide is partly reduced to another basic oxide, soluble in the electrolyte. An oxide of platinum was isolated which would produce passivity.

(5) Sackur found that with respect to the catalytic effect of metals on the union of oxygen with hydrogen the metals arrange themselves in the order Ag, Pt, Cu, Sn, Fe, Ni, Cr.

(6) As to an oxide film, Dr. Schoch says that recent work and general knowledge make it probable that oxide is formed first in the electrolyte and then deposited on the anode.

Dr. Schoch made measurements of the electrode potentials. Nickel with occluded hydrogen gives -0.48 to -0.88 volts in normal NiSO_4 ; nickel with occluded oxygen gives below -0.48 volt. Exposure to air gives about -0.25 volt. Various oxidizing agents lower the potential according to their oxidizing power.

The same considerations hold for iron. Cushman showed that iron takes oxygen from $\text{K}_2\text{Cr}_2\text{O}_7$ and lowers its potential.

Dr. Schoch has determined the equilibrium potential of nickel in an oxygen-free neutral normal solution of nickel sulphate and ascertained the effect upon the potential of various current densities, securing equilibrium in each case. Then the same was done with various additions to the nickel sulphate solution. The equilibrium point was found to be lower in acidified than in neutral solutions. Concerning details of Dr. Schoch's investigation reference must be had to the complete paper which will be published in the *Transactions*. The paper was briefly discussed by Dr. Bancroft and Dr. Patten.

Chemical Energy.

A paper on this subject by Dr. J. E. MILLS, of the University of North Carolina, was presented in abstract by Dr. J. W. Richards.

Dr. Mills, who has published during the last years a series of highly theoretical papers in Dr. Bancroft's *Journal of Physical Chemistry*, explains in the present paper his theories by applying them to the special case of the reaction between 16 grams O and 2 grams H at 0°C . under atmospheric pressure, forming 18 grams H_2O and setting free 68,511 calories. At other temperatures and under other conditions of pressure and volume the amount of heat given out would be different. From whence came the heat given out by the reaction? Why and how does the amount of heat given out vary under different conditions? Why does not the reaction take place when the hydrogen and oxygen are first mixed? Why is an electric spark needed to start the reaction?

The total heat necessary to raise 2 grams of hydrogen and

16 grams of oxygen and 18 grams of H_2O (ice) from -273°C . to 0°C . is calculated to be

2,125 calories for	2 grams H
1,972 " "	16 grams O
2,887 " "	18 grams H_2O

The 18 grams of water at 0°C . contains, therefore, at least 2,887 calories, and since 68,511 calories of heat were given out by the reaction of the hydrogen and oxygen gases at 0°C . these gases before the reaction contained at least 71,398 calories of energy.

Of this total amount of energy, 2,125 calories were supplied to the 2 grams of hydrogen, and 1,972 calories to the 16 grams of oxygen in converting them from the solid condition at -273°C . to the gaseous condition at 0°C . This is a total of 4,097 calories. It follows, therefore, that while in the solid condition at -273°C . the oxygen and hydrogen contain at least 71,398 $- 4,097 = 67,301$ calories of energy.

The author now sketches his views why 4,097 calories of energy were necessary to change the temperature and condition of the hydrogen and oxygen as described. Without going into details of the author's calculations, he finds that we have for the total energy necessary to change 2 grams of hydrogen from the solid condition at -273°C . to the gaseous condition at 0°C . under 760 mms pressure:

Energy necessary to overcome external pressure	= 542.1 calories
Energy necessary to overcome molecular attraction	= 261.1 "
Energy necessary for translational motion....	= 814.0 "
Energy necessary for internal work.....	= 514.6 "
Total	2,136.8 calories

This agrees exceedingly well with 2,125 calories, found above.

An exactly similar calculation for the oxygen gives 1,802 calories, instead of 1,972.

Unfortunately, the author's calculations cannot be extended to water, for it is an associated substance.

Except for the discrepancy of 170 calories, he has "shown why and how the 4,097 calories of energy added to the hydrogen and oxygen to change them from their condition at -273°C . to their condition at 0°C . were expended, and have, therefore, in part at least, answered the question as to why and how the amount of heat given out by the reaction of the hydrogen and oxygen will vary under different conditions of volume, temperature and pressure."

"The answer to the third question as to why the reaction did not take place when the hydrogen and oxygen were first mixed and before the passage of the electric spark, has doubtless occurred to everyone. It was first necessary to loosen the union of some of the hydrogen atoms from their combination with other hydrogen atoms, and the union of some of the oxygen atoms from their combinations with other oxygen atoms. Then once free, the hydrogen atoms and the oxygen atoms unite, and in so doing give out enough heat to loosen the neighboring hydrogen and oxygen molecules, and these in their turn unite, and thus the reaction is propagated.

"But it is perhaps not so clearly recognized that the force which we call chemical affinity is probably never directly affected by a rise in temperature. Certainly in the case under consideration we have accounted for all of the energy added to the hydrogen and the oxygen from -273°C . to 0°C ., save 170 calories, as having been used to effect external work, overcome molecular attraction, and effect an increase in the translational and internal motion of the molecules, and the original 67,300 calories possessed at -273°C . appears to have been held,

intact as it were, neither increased nor diminished, by the changes of temperature, pressure and volume necessary to raise the hydrogen and oxygen to their condition at 0° C."

The author, therefore, appears to advocate the general rule that the energy of a reaction can always be considered as the sum of two quantities, one being the energy of "chemical affinity" and being independent of the temperature, etc., the other being the equivalent of the external and internal work of the physical change from absolute zero to the conditions of the experiment.

The paper is concluded by some general discussions on chemical energy.

In the following we give an alphabetical list of the names contained in the last printed list of members and guests in attendance:

The paper was briefly discussed by Dr. J. W. Richards and Dr. L. F. Guttman.

Equilibria in Standard Cells.

A paper on this subject was presented by Dr. G. A. HULETT, of Princeton University.

Previous work had given some evidence which indicated that the cathode system of the Weston or cadmium cell was in unstable equilibrium. The materials used are cadmium sulphate, mercurous sulphate, mercury and water; and they should form a non-variant system at any temperature, provided there was no other reaction than the formation of a saturated solution of the two salts.

It was found, however, on rotating this system that the potential between the mercury and the solution did not remain constant, but showed an increasing value which indicated that the mercury concentration in the solution was slowly increasing and this change was thought to be due to a slow hydrolysis of the mercurous sulphate. This view was strengthened by the observation that the addition of sulphuric acid to the system entirely prevented the changes caused by rotating the system.

All the evidence obtained was based on the change of potential between the mercury and the solution, but further evidence has now been obtained by analyzing the solution. A method was devised by which it was possible to obtain an exact determination of the mercury in the cathode system of the cadmium cells and the solution has been analyzed for CdSO_4 , Hg_2SO_4 , and water, also the density, conductivity and potential of the solution against mercury was determined. The solution from the rotated system was found to contain an excess of mercury amounting to 30 per cent of the normal solubility.

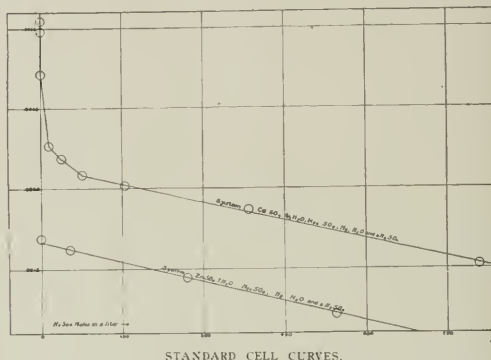
Also systems to which known amounts of acid were added were brought to equilibrium at 25° and the solutions analyzed and thus the concentration of CdSO_4 and Hg_2SO_4 as a function of the H_2SO_4 concentration was obtained. The cadmium sulphate gave a continuous curve, its concentration decreased uniformly with the increasing acid concentration, but the mercurous sulphate curve showed a distinct break at 0.08 moles of sulphuric acid in a liter. The curve for greater concentrations than this was a straight line showing an increasing concentration of mercury in the solution with a decreasing acid concentration while at 0.08 moles of acid in a liter the curve took a sharp upward turn indicating that hydrolysis takes place whenever the acid concentration is less than value. These results quite confirmed the conclusions drawn from the rotation experiments and gave quantitative data which explained the behavior of the cadmium cells, in particular the fact that some of these cells go to a very low value, and also the appearance of a yellow coloration in the paste.

Similar experiments were made on the cathode system of the Clark cell, but the curve of mercury concentration in the solution, as a function of the acid concentration, did not show irregularities and thus confirmed the rotation experiments with this system. These results indicated that the cathode system of the Clark cell was reversible, while the cadmium cell was

not, and some direct experiments to test this conclusion were made and showed that the conclusion was correct.

Cadmium and Clark cells have been made at intervals for five years, according to the specifications proposed by Carhart and Hulett (*Trans., Amer. Electrochemical Soc.*, 5, 59). The main object of these specifications was to avoid the presence of the basic salt in the depolarizer. The reproducibility of the Clark and cadmium cells has been about the same—1 part in 50,000—but the Clark cells have been the most constant.

The cadmium cells made at the various times now show values ranging from 1.01843 to 1.01827 (25°), and this does not include any of the cells which had fallen to a very low value and were rejected. Some cadmium cells have been made with sulphuric acid and these have been more constant, but for ac-



curate work one must have a constant temperature bath for either cell and with modern thermostats the old objection to higher temperature coefficient of the Clark cell has lost its force. The unsaturated cadmium cell which has practically no temperature coefficient is the most satisfactory laboratory instrument (*Phys. Rev.*, 27, 33). For very accurate work the value of this standard battery may be controlled from time to time by a standard cell.

Some remarks on the paper regarding applications of the phase rule were made by Dr. W. D. Bancroft.

Fixation of Atmospheric Nitrogen.

Prof. G. W. MORDEN, of the University of Toronto, Canada, presented an interesting paper on the formation of nitric acid from air by means of low-voltage direct current. This investigation was carried out in the laboratory of Prof. Haber in Karlsruhe, Germany.

The use of the low-voltage, direct-current arc for oxidation of the atmospheric nitrogen is a novel and very interesting departure and the success obtained by the author on a small laboratory scale is significant. Unfortunately the paper had not been printed in advance, and we are therefore unable to give here the tables of figures in which the results of the author are summed up. We intend to give them in a future issue.

However, the leading idea of the work done by Dr. Haber and his co-workers in connection with the Badische Anilin u. Soda Fabrik may be sketched here. (See also Haber and Koenig, *Zcit. f. Elektrochemie*, Oct. 9, 1908.) Formerly it has been supposed that the reaction between the nitrogen and oxygen in the air is a purely thermal effect; i. e., the electric discharge produces a very high temperature and at this very high temperature a mixture of oxygen and nitrogen is in chemical equilibrium only if it contains a certain proportion of nitrogen oxide. This proportion is the higher the temperature. Hence, when the electric discharge passes through air, the air is heated and an amount of nitrogen oxide is formed, corre-

sponding to the equilibrium at this high temperature. If now the mixture of air and nitrogen oxide would be slowly cooled, the reverse reaction would take place; the nitrogen oxide would be dissociated again and the useful work would be undone. If, however, we cool the mixture of air and nitrogen oxide very suddenly, the reverse reaction has not time to go on. And if the gas mixture is cooled very suddenly to a sufficiently low temperature then at this low temperature the reaction velocity between the different constituents of the gas mixture is so low that the constitution of the mixture undergoes practically no further change. To borrow a term from steel practice, we have quenched the gas mixture and thereby frozen the equilibrium corresponding to the original high temperature. This view seems to be, indeed, the correct one for all processes (like the Birkeland-Eyde process) in which a very high temperature, that of the electric arc, is made use of. All such processes must therefore be based on two principles: first, to produce as high a temperature as possible, and then to cool as suddenly as possible.

However, it seems now that the above theory does not tell the whole story. By electric discharges at lower temperatures it is possible to produce a concentration of nitrogen oxide in the gas mixture greater than would correspond to the pure thermal equilibrium at that temperature. It seems, therefore, that besides the thermal effect, we have a specific electric effect (perhaps an "ionic reaction"). At high temperatures the thermal effect prevails, at lower temperatures the specific electric effect. At lower temperatures we have, according to Haber and Koenig, an "electric equilibrium" different from the "thermal equilibrium." To the electric equilibrium corresponds a higher proportion of nitrogen oxide in the gas mixture than to the thermal equilibrium. The electric equilibrium in order to exist requires, however, the supply of a certain amount of energy per unit of time.

Haber and Koenig (*Zeit. f. Elektrochemie*, Oct. 9) succeeded to get the uncommonly high nitrogen oxide content of 10 per cent from ordinary air and $1\frac{1}{2}$ per cent from a mixture of equivalent amounts of nitrogen and oxygen; and these results were obtained at temperatures which were not more than a few hundred degrees above the melting point of platinum. This is a temperature region in which the dissociation of nitrogen oxide is relatively slow. Haber and Koenig used a cooled high-tension arc at reduced pressure.

Prof. Morden's results, obtained with a low-tension direct-current arc, also appear to point to a specific electric effect, different from the thermal effect.

The chief result of this whole series of investigations appears to be of practical importance. It means that it may no longer be necessary to use extremely high temperatures, so that the great difficulty of the sudden cooling is avoided. It also means that we can hope to get at lower temperatures better results than could be expected on the basis of the pure thermal theory.

The paper of Prof. Morden was discussed by Messrs. Cushman, Lidbury and Guttman mainly with respect to the arrangement of the experiments.

Corrosion of Iron and Remedies.

The afternoon session was almost completely devoted to a symposium of papers on the corrosion of iron.

Prof. A. F. GANZ, of the Stevens Institute, introduced the subject by a general discussion of "the corrosion of underground structures." He distinguished between corrosion due to an electric current from an outside e.m.f. (for instance, electric stray currents from tramway rails used as return circuit), and corrosion without an outside source of e.m.f. The latter is generally called common rusting. This distinction is simply practical. It has nothing to do with the theoretical question, whether all corrosion of iron and steel is essentially an electrolytic phenomenon or not.

An electrical engineer, called to report on a case of alleged

electrolytic corrosion due to stray currents, has first to make potential measurements to determine the electrical conditions of the system, and if he finds that there is danger of electrolytic corrosion due to the current leaving the iron structure at some point he has to propose remedies.

Prof. Ganz called attention to a ridiculous method of electric testing which has been employed by certain "experts" in electrolysis reports in this country. They measured the potential difference between the rail and the gas or water pipe alleged to be in danger, then measured the resistance between the same points and called this the earth resistance, and then derived by Ohm's law an absurd value for the current alleged to flow from rail to pipe; this was done from block to block and by adding all the currents thus calculated, an absurd value of total current was found.

The steel foundations of buildings have not the same opportunity to pick up stray currents as gas or water pipes, but there may be danger in certain cases when the steel structure is in contact with gas or water pipes. It seems a safe rule to insulate the steel structures of buildings from piping systems.

Prof. Ganz then made some suggestions as to possible remedies and discussed their dangers. He then proposed the following five questions, which are important and which should be answered by electrochemists:

(1) Are there any practical cases of iron buried in street soils where the iron is in the passive state, or are these conditions always such that the iron is active, so that we can correctly estimate the weight of iron destroyed on the basis of 20 lb. per amp-year? Is there any practical method by which the iron can be rendered passive? Lime has been suggested and the question is raised whether any such method can be applied in practice.

(2) Is there any means by which we can identify positively corrosion produced by electrolysis from stray currents as distinguished from corrosion produced by natural causes?

(3) Can an iron structure be coated in such a way as to protect it permanently from electrolytic corrosion? It is claimed that attempts to coat with paints, pitch, tar, etc., have failed. Is this failure due to actual defects in the coating, although these may appear perfect? Can corrosion of iron once begun continue if the iron is imbedded in a heavy coat of material, like pitch or asphaltum?

(4) Can the continuity of an underground iron system, such as a system of gas or water pipes, be sufficiently broken up in a practical manner to render these safe from electrolysis?

(5) What is a safe current density, per square foot of pipe surface, leaving pipe which will not produce an appreciable destruction from electrolytic corrosion?

In the discussion which followed, Messrs. Cushman and Toch emphasized their conviction that all corrosion is electrolytic in nature. With respect to question (3) of Prof. Ganz, Mr. Maximilian Toch referred to a pipe line of a natural gas company in Illinois. This pipe had been coated inside and outside with asphaltum, but it had been overlooked that natural gas is a powerful solvent for all bituminous compounds. The pipe naturally became clogged and useless after a time. Mr. Toch believed that it was quite feasible to thoroughly protect an iron structure against any possibility of corrosion, if only the interested parties are willing to pay for it.

Prof. Ganz mentioned a special case in which a single pitting in a pipe caused \$50,000 damage indirectly. In such cases companies would certainly be willing to spend any reasonable amount of money for protection of their pipes, though such expensive methods might not be recommended for gas and water pipes in general.

Mr. Carl Hering answered question (5) of Prof. Ganz by the decisive statement that there is no safe minimum current density. Whatever the current density, when current leaks from pipes into wet ground, it will cause corrosion and if the action lasts only long enough destruction of the pipe will result. A possibility of protecting an iron pipe is to put it in metallic con-

tact with a block of zinc buried in the ground; for well-known electrochemical reasons any current passing through the pipe will tend to pass out into the ground from the zinc, instead of from the iron. The iron is thus protected, but at the expense of zinc, and the protection ceases when the zinc has been consumed. If pipes are properly coated with a paint or the like, the electrolyte in the earth may be prevented from coming into contact with the iron pipe, but there is always danger that by some mechanical accident the paint coating is scratched off or otherwise removed, and such places become naturally places of serious danger. When a pipe is found in danger in one place, it may be protected there, but great care should be taken to see that the danger is not simply shifted somewhere else.

With respect to question (2) of Prof. Ganz, Mr. R. H. Gaines mentioned the case of a pipe line in New York State where the appearance of corrosion was just that of corrosion due to stray currents, yet there was no tramway line in the neighborhood, and the millivoltmeter did not indicate a potential difference between the rail and ground.

Messrs. Roberts, Bancroft and Sadtler also participated in the discussion. Mr. S. S. Sadtler referred to an interesting case where corrosion resulted at a point where current was entering the pipe, not leaving it, i. e., where the pipe was cathode. The explanation was that the ground contained a sodium salt. The sodium set free at the cathode alloyed with the iron and this alloy disintegrated chemically.

Dr. CLAYTON H. SHARP, of the Electrical Testing Laboratories, of New York City, then presented a paper of "correct methods for measuring stray currents."

The investigation of the electrical conditions of a system of water or gas pipes in the ground is not easy. The chief thing to find out is whether at any point any considerable amount of electric current leaves the pipes. The principal measuring instruments available for such tests are the voltmeter and the millivoltmeter. They have been used by would-be "experts" with alarming results, but when properly employed they can give valuable indications.

When the voltmeter shows that the rails of a trolley line are positive with respect to the system of pipes, the pipes are safe. On the other hand, if the pipes are positive with respect to the rails or other steel structures, the pipes may be in danger. But danger does not necessarily exist in this case, since the pipes may be embedded in dry sand and thus insulated.

The determination of the current flowing in a piping system is more difficult. The easiest way would be to insert an insulating joint in the pipe and connect the ammeter to points at both sides of the joint. But this is often not feasible. It is then necessary to employ an indirect method.

One indirect method is to measure the potential drop along the line. If the ohmic resistance per unit length of pipe is known, the current in the pipe is found by Ohm's law. But the measurement of resistance per unit length is the difficulty in this case. However, it may be estimated from the size of the pipe and from an average value of resistivity, although the resistivity varies considerably in practice.

In some cases it is possible to connect by wires two points of the pipe with an ammeter. The potential difference between the points of connection is measured both when the ammeter circuit is closed and when open; and in the latter case the current is simultaneously measured. In the latter case the potential difference is smaller than in the first case, and from this difference the resistance of the pipe between the two points of connection may be found. For instance, if the potential difference with closed ammeter circuit is half the potential difference with open ammeter circuit, it follows that the current flowing originally in the pipe is twice that indicated by the ammeter reading.

However, more important than the current flowing through a pipe is the current leaving the pipe. Important information may be obtained by determining the electric conditions of the

soil in the vicinity. By determining the potential gradient around the pipe we do not disturb the electrical conditions in the soil, and if we find that there is a continuous drop of potential, by passing from point to point away from the pipe, we can conclude that current flows away from the pipe. Non-polarizable electrodes should be used in such cases.

Dr. Haber's "earth ammeter" is valuable, but would seem to change the electrical conditions in the soil.

Dr. Sharp's paper was discussed by Mr. Hering, who doubted the practicability of the shunt method. Dr. Sharp answered that it can be used in some cases and not in others. We have no standard method which can be used in all cases, but must adapt the method to the conditions of each special case.

Mr. A. A. KNUDSON then presented a paper describing some particular cases of the corrosion of the bottom of oil tanks and some other structures. The paper was briefly discussed by Messrs. Sadtler, Hering, Cushman, Burgess, Walker and Richards. Mr. S. S. Sadtler referred to the usual conditions of the soil around an oil tank and thought that a good deal of the corrosion may be purely chemical, that is, not caused by external stray currents.

Dr. W. H. WALKER, of the Massachusetts Institute of Technology, then presented a very interesting paper on "the function of oxygen in the corrosion of metals."

Dr. Walker spoke in a very forceful and interesting way and first criticized severely a recent investigation in which it was claimed the electrolytic theory of the corrosion of iron had been refuted.

Dr. Walker then discussed the function of oxygen in the phenomenon of corrosion. This function is twofold. Oxygen is necessary for rusting; according to the electrochemical theory the first action is the passing of iron into the ferrous ionic state, with simultaneous liberation of hydrogen; the ferrous ions are then oxidized to the ferric state by oxygen in the atmosphere, with its subsequent precipitation as ferric hydroxide. This is the evident secondary function of oxygen.

But according to Dr. Walker oxygen also has to fulfill a primary function in the corrosion of iron.

The rapidity with which iron will pass into solution in water depends not only upon the electrolytic solution pressure of the iron and hydrogen and the osmotic pressure of the iron ions already in solution, but also upon the "excess voltage" (Überspannung) which is required in order that the hydrogen ion which passes from the ionized condition may be set free. In this case there is a counter e.m.f. which must be overcome before the hydrogen can be liberated. It is possible, therefore, that the quantity of iron which can dissolve in water is limited to that amount which is equivalent to the hydrogen necessary to polarize that portion of the specimen which acts as the cathode. If this is so, it must be possible to make a solvent action continuous by the addition of any reagent which will dissolve the hydrogen-covered cathode portion.

The primary function of oxygen is, therefore, to depolarize those cathodic portions of the iron upon which hydrogen tends to precipitate. Dr. Walker described some instruction experiments quite similar to those described by him in our Vol. V, page 364.

In the second part of his paper Dr. Walker discussed several practical problems. One of these was the corrosion of barb-wire fencing. The zinc protects the iron, but at the expense of the zinc. The more rapidly zinc passes into solution, the more iron surface is exposed, and so on. The zinc-iron alloy (produced in the hot galvanizing process) dissolves with greater rapidity than pure zinc. To solve the problem of the corrosion of barb-wire fencing, Dr. Walker suggests to deposit zinc on the ends of the barbs by a special short treatment in wet galvanizing tanks.

Incidentally it was remarked that manganese in contact with iron protects the iron. But if manganese is found in steel, it means the presence of other impurities.

Mr. MAXIMILAN TOCH, of the well-known firm of Toch

Brothers, finally presented a paper on "simple methods for the prevention of electrolytic corrosion," principally by the use of paints.

The chief point, according to Mr. Toch, is that if it is possible to keep water away from the steel structure, no corrosion can result.

As to the protection obtained with concrete, Mr. Toch explained that we should not say that concrete protects, but that cement protects.

If a steel pipe or structure is first painted with an insulated paint and then embedded in pure cement, this covering should protect it for all time.

Mr. Toch said that he had not found that the chromate treatment of Dr. Cushman prevented corrosion. Steel beams and other materials are subject to so much rough handling in course of transportation that a very thin inhibitive surface film cannot be expected to afford a really lasting protection.

Electrolytic Paints.

Dr. WILDER D. BANCROFT, of Cornell University, in a paper on "the theory of electrolytic paints," gave an outline of the work which he proposes to undertake. The objection generally raised against electrolytic white lead is that it absorbs too much oil.

Dr. Bancroft thinks we should first make white lead that beats the standard and then consider the cost. It is really ridiculous that we should not be able to make on a small scale in the laboratory the ordinary white lead of commerce.

The principal thing in the experimental research is to study in detail the effects which a change of the different conditions of the experiment has on the properties of the product. For instance, the effect of variation of temperature should be thoroughly studied, and the other conditions should be similarly varied.

In experiments with copper oxides, Dr. Bancroft succeeded in producing a wide range of different colors by changing the conditions.

The Lash Steel Process and the Electric Furnace.

The first paper of the Saturday session was presented by Mr. F. A. J. FITZGERALD, of Niagara Falls.

His paper was not intended to do more than give a description of the general principles of the Lash process and describe briefly certain experiments on its application to the electric furnace. (See our Vol. V, pages 279, 322, 344, 378, 440, 455, 479 concerning further details of the Lash process.)

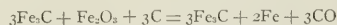
There are certain misconceptions as to what the Lash process is, and also it is not obvious at first sight why it might be of interest to the electrometallurgist. As regards its use in the open hearth, little may be said here beyond mentioning that the experiments, made on a commercial scale at several steel plants, have been successful in demonstrating its usefulness. "As might be expected, a process of this kind inevitably gives an opportunity to the person who is convinced that he did the same thing twenty or thirty years ago, but discussions on that subject are of more interest to the archeologist or mythologist than to the electrometallurgist, and in any case are not usually profitable."

The broad principle of the Lash process consists in making an intimate mixture of ore, cast iron and carbon and submitting this mixture to heat, when, if the proportions of the constituents of the mixture have been properly adjusted, the desired grade of steel is produced. The essential features in the process seem to be the fine state of division of the constituents of the mixture, their intimate association and the use of iron containing metalloids in considerable quantities.

It is unnecessary to comment on the advantage of having the various reagents in a fine state of division and intimately mixed, for the value of such a condition may be readily appreciated; but the use of iron, containing metalloids, is worthy of more extended notice. According to Lash (U. S. Patent 860,922, December 28, 1906): "The action of the pig- or cast

iron in the finely divided mixture is two-fold in character: First and primarily the pig iron contains a high percentage of metalloids and, generally, manganese, which elements upon the fusion of the iron are presented to the oxide in the most intimate and effective condition possible and become active and ready reducing agents. Secondly, the fused pig iron seems to act simultaneously as a solvent for some of the free carbon, and as an enveloping coat for the individual particles of oxide, thus bringing such dissolved carbon into intimate association with the oxide to supplement the effect of the metalloids already contained in the pig iron, in their reducing action."

Thus, according to this hypothesis as to the working of the process, the finely divided iron acts as a carrier of the carbon and the reactions might be represented by an equation as follows:



It follows then that during the reaction all the iron present in the metallic state contains carbon in excess of that required in the finished product till towards the end, when the free carbon



FIG. 1.—HÉROULT FURNACE TAPPED.

is completely exhausted and there is simply a mixture of iron high in carbon and unreduced oxide. Finally, this mixture reacts and the desired quality of steel is obtained. While the reactions which actually take place are no doubt far more complicated than this hypothesis of the working of the process, yet the experiments which have been made seem to demonstrate the usefulness of the supposition.

In practice there are many details which have not been mentioned as, for example, the addition of fluxes such as lime and fluorspar to the mixture; the use of sawdust, which is carbonized in the furnace and leaves the mass in a porous state so as to permit of the ready escape of the gases formed; the use of coal tar or any other suitable material to prevent the separation of the constituents of the mixture from each other because of their widely-differing specific weights or to act as a binding material in briquetting. These details, however, need not be considered at present.

In the application of the Lash process to the open-hearth furnace the saving effected is due to the lower cost of a unit of iron in the form of ore, than in that of pig or some forms of scrap. From this it follows that, other things equal, the less pig iron and the more ore that can be used the cheaper will be the steel produced. As to the arguments which may be advanced, that the process cannot compete with an open-hearth furnace fed with molten pig iron, or with other modifications of the open-hearth furnace, they are foreign to the present

considerations. The expert steel maker may also discuss the correctness of the observation that steel obtained directly from a charge containing a much larger excess of ore than is possible in the ordinary open-hearth method possesses superior qualities to that manufactured in the usual way. The contention may be difficult to support *a priori*; but some empiricists are nevertheless convinced of its truth, and even when they admit the possibility of making good steel from any kind of raw material make inconvenient inquiries as to what it costs.

That it is possible to produce steel directly from iron ore in the electric furnace is well known. This has been done by various electrometallurgists, but the best published account of that work is by Major Stassano. According to his most recent publications (this journal, Vol. VI, No. 8, page 315) the best results obtained in the production of steel, where the charge consisted essentially of ore and carbon, showed an energy consumption of 4 kilowatt hours per kilogram, or 0.62 horse-power year per gross ton. The cost of lining the furnace, as calculated from a long series of experiments, amounted to \$1.93 per ton (metric?) of output.

The experiments made with the electric furnace in the production of pig iron at Sault Ste. Marie, under the auspices of the Canadian Government, have shown the possibility of producing a ton of metal from a mixture of ore, carbon and fluxes with an expenditure of less than 0.28 horse-power year. Now it seems reasonable to suppose that if by using the Lash process in the electric furnace an energy consumption comparable with that of the electric iron furnace should be obtained, the fields of usefulness of the electric furnace in the metallurgy of iron and steel would be greatly extended.

One of the most serious difficulties experienced in all processes where the reduction of iron from the ore with the object of producing steel directly is aimed at, is the serious loss of iron which occurs so that the yield of metal is too small. So far, however, as the Lash process is concerned there was little reason to fear a difficulty of this kind, for in the preliminary experiments made at our laboratories on a small scale it was found that 98 per cent of the iron contained in the mixture could be easily obtained.

This may be readily seen when it is pointed out that in these experiments the metal and slag were carefully preserved and weighed, and that it was found that the total loss of metal in the slag only amounted from 0.3 to 0.6 per cent of the iron contained in the mixture put in the furnace. So far, therefore, as the electric furnace was concerned the chief point to be determined was the amount of energy required to obtain one ton of steel.

In order to investigate this matter, there was a choice of various furnaces, for it was decided that to get results of any value it was necessary to work on a scale which would produce steel in commercial quantities. The possible furnaces seemed to be those of Girod, Héroult, Keller, Röchling-Rodenhauser and Stassano. For various reasons it was decided to use a Héroult furnace, shown in Fig. 1.

With this plant there were manufactured about 50 tons of steel having various analyses, of which a few are given in the following table:

HEAT NO.	9	11	23	27
Carbon	0.10	0.08	0.92	0.22
Manganese	0.75	0.00	0.41	0.94
Phosphorus	0.015	0.015	0.038	0.033
Sulphur	0.070	0.007	0.026	0.056
Silicon	0.02	0.00	0.13	0.03

The following tests were made from bars 1 inch square hammered from 6 x 6 inch bottom cast ingots. The elongation was determined in a length of 2 inches:

Heat No.	Tensile Strength.	Elastic Limit.	Elongation per cent.	Reduction per cent.
9	57000	34000	33	58
27	77000	45000	28	56

The steel of heat No. 27 was treated with 0.1 per cent of titanium.

In all twenty-six runs were made, the methods of working the furnace being varied so as to investigate the working of the Lash process under as widely differing conditions as possible. Naturally such a method of experimenting was not conducive to the highest efficiency of working, but nevertheless it



FIG. 2.—THREE-PHASE RÖCHLING-RODENHAUSER FURNACE.

was possible to obtain complete reduction of the charge with an expenditure of 0.27 horse-power year per ton of steel, and turned out a finished product with an energy consumption of 0.33 horse-power year per gross ton of steel cast.

In all the experiments there was an excessive expenditure of energy in the process of finishing the steel, adjusting the carbon, removing phosphorus, etc. Making due allowances for the difficulties under which the experiments were carried out, such as inadequate apparatus, inexperienced workmen, variation of the method in every experiment, it is believed that under suitable conditions a production of 4 tons of steel per horse-power year can be reached.

Fig. 1 shows the furnace in process of pouring the steel into the ladle. The photograph was taken by Mr. J. R. Wilson, who did most of the construction work on the plant.

A serious problem met with in the working of the process in the Héroult furnace was the wear of the carbon electrodes, which in many runs was excessive. This was found to be due to various causes, but more especially to the inadequate apparatus for adjusting the electrodes and to certain faults in the method of working the furnace. Experiments made with a view of correcting the latter cause showed such an astonishing decrease in the electrode consumption that it is reasonable to believe that while the best results obtained in the experiments showed a consumption of 69 pounds per ton of steel cast, this may be brought below 50 pounds per ton.

Another very important consideration in the process is the wear of the lining, but unfortunately there have not been a sufficient number of runs made to obtain an accurate estimation as to what this item will amount to.

In carrying out the Lash process in the electric steel furnaces of Keller and Girod the conditions would be very similar to those met with in the Héroult furnace; but in the Stassano furnace the electrode problem would probably be much simpler since these are held some distance above the charge. Whether the consumption of energy would be as low as in the Héroult furnace is another question; but it seems certain that the cost of producing steel would be less were the Lash process used than when working with the simple direct method.

"While the electrode problem can, no doubt, be successfully solved, its existence emphasizes the interest of a furnace which can be worked without these troublesome and expensive appendages." The Colby-Kjellin induction furnace would obviously be unsuitable for use with this process, because it does not permit the handling of slags in a convenient and economical manner, but the modification of this apparatus, known as the Roehling-Rodenhauser furnace, might be expected to give interesting results. Fig. 2 shows a three-phase furnace of this kind, the three channels forming the secondaries of the induction furnace being connected to a central bath which is so constructed that the slag formed during the reduction of the ore can be handled. Moreover, this central bath would also permit of the easy introduction of the charge, which would probably be in the form of briquettes. (For further details of this furnace see our last issue, page 458.)

Mr. FitzGerald showed some excellent cold-bending tests of Lash-process steel; also one bent bar of steel which had been treated with 0.1 per cent of titanium in the ladle, with a curious fibrous structure resembling wrought iron.

In the discussion which followed Mr. Fitz-Gerald's paper Mr. Hy. D. Hibbard compared the electric furnace with ordinary metallurgical furnaces with their oxidizing atmosphere, like the open-hearth. In the open-hearth furnace oxygen is the active element. In the electric furnace we have the possibility of producing heat without oxidation. This is very important practically. The chief trouble with the electric furnace is the capital investment required. Mr. Hibbard also thought there was some similarity between the Lash process and the old Uchatius process.

Dr. J. W. Richards spoke of steel making by two different processes.

One is to melt the desired ingredients together, as in the crucible process, or in the simple induction furnace. The other evolves elimination of impurities. Both processes require different kinds of apparatus. The second requires essentially a large surface.

Prof. W. S. Landis thought the loss of iron in the slag would be serious. Mr. FitzGerald explained that in the first experiments with the Lash process in Niagara Falls considerable iron (up to 15 per cent in some cases) passed into the slag. This was diminished later to some 6 per cent. A reduction of the loss of iron in the slag accompanied the reduction of the power consumption. Dr. J. W. Richards thought the loss of iron in the slag was not serious. This loss is considerable in the open-hearth furnace. In the Monell process the loss is some 15 or 20 per cent, but the process is successful.

Dr. Richards thought that to make electric steel furnaces successful co-operation is necessary between the electrometallurgist, who knows all about the electric furnace, and the practical steel man, who knows all about steel making.

Mr. FitzGerald explained that the mixture used in the experiments at Niagara consisted of 60 per cent of iron ore, 23 per cent of cast iron (in form of borings or shotted pig iron), the balance being fluxes and carbon.

Vaporization of Zinc.

The following paper was presented by Mr. Woolsey McA. JOHNSON, of Hartford, Conn., who, in studying the condensation of zinc vapor from all sides of the problem, scientific, commercial and practical, has calculated the latent heat of vaporization of zinc by use of thermodynamics as follows. This calculation was necessary, since the value has never been determined experimentally.

His calculations are based on the following formula, which is a direct consequence of the second principle of thermodynamics:

$$e = T \frac{dP}{dt} (v - v')$$

where e the latent heat of vaporization at 760 mm pressure, $v - v'$ the change of volume during vaporization, T the abso-

lute temperature of the boiling point at 760 mm pressure, and $\frac{dP}{dt}$ the increase of pressure needed to keep zinc liquid for increase of temperature by 1°C . at the boiling point.

The boiling point of zinc at atmospheric pressure is 920°C ., hence in the absolute temperature scale it is $T = 920 + 273 = 1193^\circ$.

The value of $\frac{dP}{dt}$ at this temperature was found by Mr.

Johnson to be 0.152 lb. per square inch increase of pressure per degree centigrade.

On the basis of these data the latent heat of vaporization of zinc becomes $e = 451$ calories per gram of zinc.

Barnes has also determined the value of $\frac{dP}{dt}$ (Bull. U. S.

Geol. Survey, No. 54, March 10, 1889). On the basis of his results, Mr. Johnson's calculation gives a latent heat of vaporization $e = 388$.

Prof. J. W. Richards has estimated the latent heat of vaporization of zinc on the basis of Trouton's law and found it to be $e = 426$. It can, therefore, be assumed that the mean of 426, 451 and 388, or 422, is a figure close enough to the actual value for practical purposes.

In order to condense zinc practically on a large scale, it is necessary to study the physical chemistry of the problem and also to have due regard for the engineering and commercial side. The latter is, of course, the acid with which to test your theories.

Heat Conductance Through Walls of Furnaces.

Mr. CARL HERING, consulting engineer, of Philadelphia, presented a paper on the calculation of the heat conducted from the interior to the outside of a furnace through its walls.

In calculating the loss of heat through the walls, the cross-section of different parts of the path of the heat vary very greatly, as the walls have a small surface on the hot side and a large one on the outside. For all but large and relatively thin-walled furnaces this variation in cross-section is very great. To use the ordinary average cross-section, that is, the arithmetical mean, as is usually done, is not rigidly correct.

The purpose of Mr. Hering's paper is to give the rigidly correct results, to reduce important and useful relations from them, and to compare the correct results with those obtained from the approximate formulas in which the simple arithmetic mean is used. The error in using the approximate formula varies greatly, being sometimes negligible and at other times very large, amounting to several hundred per cent.

The well-known formula for calculating the conduction of heat through bodies is

$$H = \frac{S}{l} kt \quad (1)$$

in which H represents the gram calories per second which pass through from one side to the opposite one, if no heat is lost on the way; S is the cross-section of the body in square centimeters; l its length in centimeters, k the conductivity found in tables which signifies the calories per second which will pass from one side of a cubic centimeter of the specific material to the other, for 1°C . difference of temperature, there being no loss of heat through the other four sides of the cube; t is the difference of temperature between the two faces, in Centigrade degrees.

Of all these quantities, S and l are purely geometric; that is, they are mere dimensions and have nothing to do with any physical constants, they are constant for a body of any given shape and are independent of the temperature, the material or any other such factors. Hence, they may be considered by themselves, and the relations between them will always be the same for all bodies of like size and shape. The present paper deals with this relation of S and l in such shaped bodies as constitute the walls of furnaces. The difficulty in determining the loss of heat through irregularly-shaped bodies, like frus-

trums, lies in this relation of S and l , and when this has been determined the rest of the calculation becomes very simple.

This quantity S/l in the above formula signifies the conductance of any particular body of a given shape and size, for a conductivity equal to unity. It might be called a conductance factor. When thus considered it can be calculated for a body of any particular shape, and then is that number which, when multiplied by the conductivity k , gives the total conductance of that body; and when this conductance is again multiplied by the difference of temperature, it gives the flow of heat through the body. In Mr. Hering's paper the true values of this

$$R = \frac{r}{2\pi c} \times \text{nat. log } \frac{P}{p} \quad (3)$$

and, third, for a pyramidal frustum as above defined,

$$R = \frac{r}{\pi n} \left(\frac{1}{1's} - \frac{1}{1'S} \right) \quad (4)$$

The correctness of these formulas, as given here, is assumed.

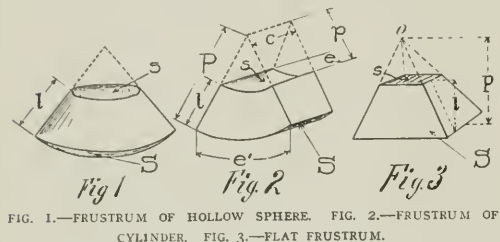
The corresponding approximate, but much simpler formula with which these are to be compared, in which the arithmetic mean is taken of the two surfaces S and s is

$$R = \frac{2r l}{S + s} \quad (5)$$

In all of these R is the resistance in ohms between the two surfaces S and s stated in square centimeters, l is the length or normal distance between the two surfaces in centimeters, r is the resistivity in ohm-cubic-centimeter units, and in the case of the cylindrical one, P is the outer, p the inner radius in centimeters, and c the axial length of this cylinder in centimeters; n is the rate of flare in Fig. 3, such that $S = nP^2$, in which P is the perpendicular distance from the center O to the surface S . All these dimensional letters are shown in the diagrams.

In order to make direct comparisons, all these formulas must be reduced to the same terms; in practice the quantities which are always known are the surfaces S and s , and the distance between them, or thickness of wall, l ; hence, the formulas should all be reduced to these common terms.

The formula for the cylinder is not in a form suitable for comparison with the others, as it is for the whole cylindrical shell and not for a portion of it. To reduce it to a fractional



conductance factor are calculated for numerous ranges of thickness in several typical cases.

It may be claimed that the value of k is so uncertain that there is no need of accuracy in the other factors of the formula. The errors in the usual way in which this conductance factor is calculated are, however, sometimes very great. Moreover, if there are several uncertain factors in a formula, the results will be more reliable the less the inaccuracies and uncertainties involved in it, and it is hoped that with the great need of more accurate values of k they will before long be forthcoming.

For the purposes of these deductions furnaces are best divided into three typical classes: spherical, cylindrical and cubical. Others must be considered to belong to the nearest typical form or calculated by themselves.

Fig. 1 shows a frustum of a hollow sphere, Fig. 2 a wedge-shaped frustum of a hollow cylinder, and Fig. 3 a flat frustum, whose two parallel sides are perpendicular to its axis and whose cross-section varies proportionally with the square of the axial length from the center O ; no other conditions are imposed and it may, therefore, have any shape of cross-section, round, rectangular or irregular. In all of them the resistance or conductance is understood to be that between the two parallel faces, the distance between them or thickness of the wall being represented by l . The smaller, or hot surface, is s , the larger, or cooler, S .

The calculation of heat conductance is, of course, directly analogous to the calculation of electric conductance. Mr. Hering bases his calculations on the following formulas from an unpublished work of Dr. E. F. Northrup for the electric resistance of these three typical forms of frustums, namely, first, for a frustum of a hollow sphere:

$$R = \frac{rl}{VSs} \quad (2)$$

Second, for a whole cylindrical shell with open ends:

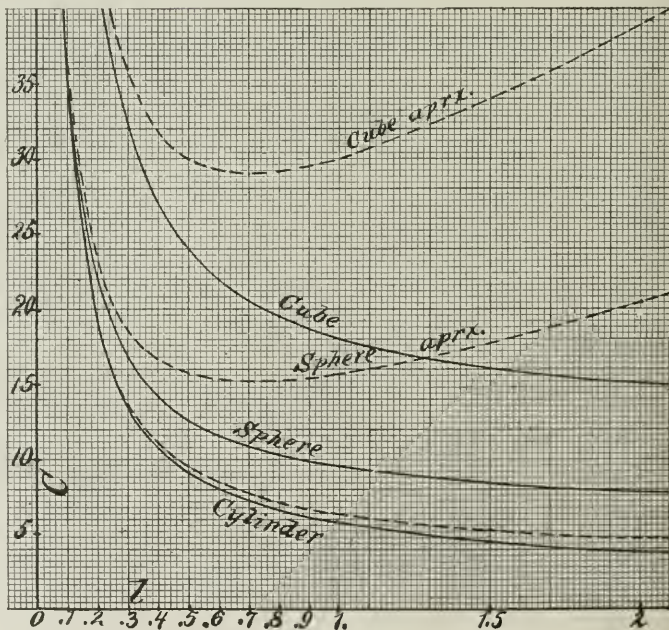


FIG. 4.—HEAT LOSS AS FUNCTION OF THICKNESS OF WALLS.

part of the circumference and to an expression which involves only the quantities S , s and l , like the others, let e be the circular length of the curved inner edge of the wedge-shaped cylindrical frustum, as indicated in the diagram; then, the resistance of the frustum will be

$$R = \frac{2\pi P}{e} \times \frac{r}{2\pi c} \times \text{nat. log } \frac{P}{p}$$

By reducing this to the terms S , s and l (by substituting S/s for P/p , s for the surface ce , and for p its value $s/(S-s)$) we get

$$R = \frac{rl}{S-s} \times \text{nat. log } \frac{S}{s} \quad (6)$$

For the cubical frustum, Fig. 3, $2l = \sqrt{B} - \sqrt{A}$, and $S = 4P^2$, hence $n=4$, and after making some simple algebraic reductions, equation (4) becomes

$$R = \frac{rl}{\sqrt{S}s} \quad (2)$$

which will be seen is the same as equation (2) above for a spherical frustum. Hence, the comparison is reduced to only two forms, the spherical or cubical, and the cylindrical. It will be noticed that in the formula for the cubical and spherical frustums the correct effective cross-section is the geometric mean between the two extremes.

All these formulas apply equally well to either frustums or to the whole of a complete body.

As the natural or Napierian logarithms are not so convenient to use, especially for fractions which may be near to unity, formula (6) may be written

$$R = \frac{2.3026 rl}{S-s} \times \text{com. log } \frac{S}{s} \quad (7)$$

These formulas all apply equally well to heat resistance, if r is the heat resistivity; that is, the reciprocal of the heat conductivity stated in c.g.s. units (grams calories per second for 1 cu. cm and 1°C.), and R is the total heat resistance in the same units. Then, the heat passing through such a body in gram calories per second is, analogously to Ohms law,

$$H = \frac{t}{R} \quad (8)$$

in which t is the difference of temperature between the two surfaces.

It must be clearly understood that formulas (1) and (8) and any deductions made from them, refer to the temperatures of the heat conductor at its two end surfaces and have no reference to the surface contact resistances between the heating or the cooling gases or liquids; these must, of course, be added if they are appreciable.

It must also be understood that the conductivity of most heat insulators varies with the temperature, sometimes very decidedly. In the formulas here given it is assumed that the conductivity is the mean for the particular range of temperature of any given case.

The present investigation, however, deals primarily only with the question of what shall be used as the mean or average cross-section in formula (1) for such frustums, or as the result cannot be given in just that form, it deals with the part S/l in that formula, and, therefore, is not concerned with either the conductivity or the temperature. It deals with the conductance for a conductivity of unity.

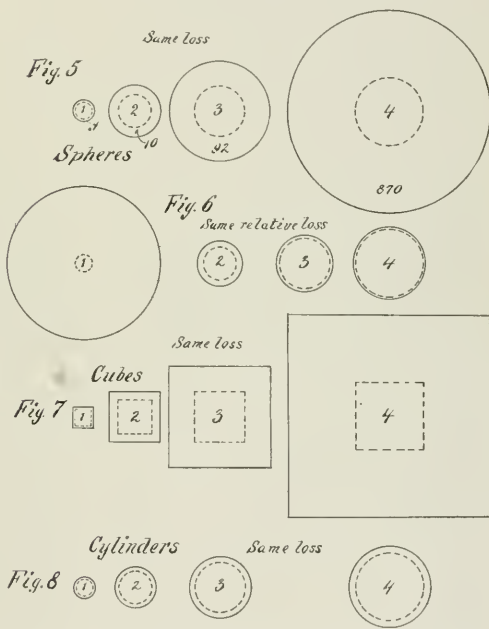
In what follows conductances will be used instead of resistances, as the former are more generally used in calculations of heat; hence, the results apply to formula (1) rather than (8), although in the opinion of Mr. Hering, when the walls of furnaces are composite, it is much simpler to use resistances instead of conductances.*

Mr. Hering has calculated tables and drawn curves for the three typical forms, spheres, cubes and cylinders, both from the correct and the approximate formulas, and for the range of thickness likely to be used in practice. In general, and for the purpose of making comparisons and reducing the number of tables and curves, the inside diameter or edge in the rectangular furnace is made the unit of comparison, and the thickness of wall l is given in terms of this diameter; thus $l=1$ means that the thickness is equal to the diameter. The thicknesses l in the

curves must, therefore, be multiplied by the diameters in any particular case to reduce them to actual inches or centimeters. On account of limitations of space we reproduce here only Mr. Hering's curves, while for the complete tables the reader must be referred to the complete paper of Mr. Hering, to be published in the *Transactions* of the society. (Of course, the curves of Fig. 4 give exactly the same figures as Mr. Hering's tables, only in graphical form.)

The curves in Fig. 4 have been so drawn to scale that they show at a glance how the heat loss diminishes as the thickness of the walls increases. For diameter of unity, the ordinates are numerically equal to the conductances for a conductivity of unity, that is, they are the numerical values of S/l in formula (1); they are, therefore, proportional to the heat losses and need only to be multiplied by the conductivity k , and the temperature drop t , and sometimes by the diameter also, for any given case to give the actual heat loss.

The distances to the right of the point O represent the thicknesses l of the surrounding walls in terms of the diameter or of the edge of the cube. Thus it will be seen that for thin walls the heat loss diminishes very rapidly as the thickness increases, but for the thicker ones the decrease of the loss be-



FIGS. 5, 6, 7 AND 8.—COMPARATIVE DRAWINGS, SHOWING SAME ACTUAL LOSS AND SAME RELATIVE LOSS.

comes very small; hence a point is reached where it would be of little value to still further increase the thickness.

The reason for this is that the real mean cross-section increases very fast for thicker walls, almost as fast as the thickness, and hence the quotient between them, namely, the factor S/l in (1), changes but very little.

Incidentally, Mr. Hering remarked here that there are two possible ways of still further decreasing this loss of heat through the walls which are the diametrical opposites of each other. One is to diminish the temperature drop t , say, by heating the outside of the furnace with cheap fuel heat, as, for instance, by placing the electric furnace inside of a gas or fuel furnace. From formula (1) it is evident that, all other things

*Concerning this point, we hope to publish an article by Mr. Hering in our next issue.—EDITOR.

being the same, the loss is less the smaller the drop of temperature t . The other method is to increase the temperature drop t , say, by water cooling the outside. Both methods have been used with apparent success. The explanation of this apparent anomaly undoubtedly lies in the value of the conductivity k . When the outside shell is cooled to a low temperature, the value k for that layer decreases and apparently more rapidly than t increases, hence their product in (1) becomes less. To determine which of these two diametrically opposite methods is the best in any particular case is a simple engineering calculation, provided the conductivity is known for that particular range of temperature. It is then merely a question of whether the product of k and t in (1) become less or greater.

The curves, Fig. 4, also enable one to find directly the value of the thickness l for any given loss, which if calculated would be quite a tedious operation for cylindrical walls, as it involves the equation $ax \log bx = c$.

The spherical type is the theoretically best form as it has the smallest cross-section of the insulator (normally to the radius) for a given interior volume. All other forms are worse; the cylinder comes next, and the rectangular, which is perhaps the most common, is the worst.

In the curves of Fig. 4 the full line represents the correct results, and the dotted line those obtained from the approximate formula. The latter, it will be seen, differs little from the true curve for small thicknesses, not used in practice, but departs very greatly from it for the more usual range of thicknesses; it even has a minimum point for a thickness equal to about three-fourths of the diameter, beyond which the loss would increase again for greater thicknesses, which, of course, cannot be correct.

In general, the loss calculated from the approximate formulas is the greater of the two, and, hence, the calculation is on the safe side. This appears to be borne out in practice in which the actual losses were found to be smaller than those calculated with this approximate formula. But the difference seems too great to be overlooked in electrical furnaces, in many of which the predetermined results are a criterion as to whether the actual construction shall be undertaken or not. In a recent case in Mr. Hering's practice the entire function of an electrical furnace was to maintain the material at a given temperature and not to do any melting or heating; hence, the amount of loss through the walls was the only heat to be supplied electrically and its correct predetermination was, therefore, of great importance. The curves of Fig. 4 show that beyond a thickness equal to a little less than the diameter, there is little to be gained.

Fig. 5 shows how very important it is to reduce the inside of a furnace to the smallest possible size to hold the necessary amount of material. It shows what the thickness of the walls of a spherical furnace must be when the inside diameter is doubled, trebled and quadrupled, and when the actual loss is the same. The increase will be seen to be surprisingly great. The volumes of the insulating material are given and will be seen to increase very rapidly, being about 2500 times as great for the largest one as compared with the smallest one. If these four hollow spheres were made of an electrical conductor, the resistance from the inside to the outside would be the same in all of them.

These diagrams, Fig. 5, are for an equal loss and merely show the great importance of not wasting any room in the inside, be the furnace a large one or a small one; they do not mean that furnaces should not be made large. The volumes of the interiors of these increase as the cubes of the diameters and, hence, are as 1 to 8 to 27 to 64. For the same relative loss, considering the increased interior capacity, that is, for the same loss per unit volume, the thicknesses will be as shown in Fig. 6. It will be seen that in this case the thickness becomes very great for the smaller ones and very small for the larger ones, becoming nearly constant. The volume of the insulation for the smaller ones is even far greater than for the larger ones.

This shows in an equally striking way the very great importance of using as large a furnace as possible; that is, it shows that the loss of heat per cubic foot interior capacity can be made very much less for a large furnace than for a small one, which means that the heat efficiency can be made much higher for the larger ones. The earth, considered as a molten mass surrounded by a solid shell, is a good illustration of this case, a relatively thin shell being sufficient to insulate it very effectively. The explanation is that the volume of the inside increases very rapidly with an increase of the diameter, hence the loss per unit volume becomes small. But it must not be forgotten that, as Fig. 5 shows, it is very important not to waste any space in it.

It can also be shown from these data that for the same relative thickness the loss in spherical furnaces increases as the diameter. That is, if the thicknesses in all of several furnaces are, say, three-fourths of the diameter, the losses will increase as the diameters; but as the cubical contents of the inside increase as the cube of the diameters, the loss per cubic foot of interior space, that is, per unit capacity, will diminish rapidly as the furnaces become larger.

To illustrate the use of the curve of Fig. 4 for the sphere by an example, let the inside diameter of a spherical furnace be 15 in.; let the thickness of the walls be 9 in.; required: the heat conductance for a conductivity of unity. The relative thickness l/d will be $9/15 = 0.6$, that is, the thickness is 0.6 of the diameter. From the curve the correct conductance corresponding to this value is 11.5; multiplying this by the diameter 15 gives 172.5 in inch units.

If this material is, say, infusorial earth, having a conductivity in gram-calorie, cubic-inch units, of $k = 0.001$, and if the fall of temperature between the inside and the outside is 700°C ., then, according to formula (1), the heat loss through it will be

$$H = 172.5 \times 0.001 \times 700 = 121 \text{ gram-calories per second.}$$

Suppose the loss is limited in the above case to 100 calories per second and it is desired to find the necessary thickness of this material to make it so. The corresponding conductance from (1) must be $100,001 \times 700 = 143$. Divide this by the diameter 15, giving 8.5. From the curve, Fig. 4, for this value of C that of l is about 0.98, hence the required thickness will be 0.98 time the diameter 15, or 14.7 in.

The curves for the cubical furnace show that the conductances (and, therefore, the heat losses) will be 1.910 times, or about twice, as great as those of the spherical form, for the same thicknesses and the same diameter or edge, but it must be remembered that the contents of a cube is nearly double that of its inscribed sphere, hence the difference is not what it seems at first sight.

Comparing a sphere with a cube whose edge is equal to the diameter of the sphere, both having the same thickness of walls, it will be found that the loss per unit of volume is the same in both. Hence, in this sense the cubical form is no worse than the spherical. A sphere and its circumscribed cube have the same surface per unit volume. But a cubical furnace whose inside volume is equal to that of a given spherical one will have an edge which is less than the diameter of the sphere; hence, for the same relative thickness of walls (l/d) the loss will be considerably greater for the cubical furnace; its conducting surfaces will be greater. It follows, therefore, that for a given interior volume, and the same relative thickness of walls, a spherical furnace is more economical in heat loss than a cubical one.

For equal losses, Fig. 7 shows the rapid rate at which the necessary insulation increases; these figures correspond with those of Fig. 5 for the sphere, and the wall thicknesses are the same.

For the same relative loss, that is, for the same loss per cubical contents, the results, corresponding with those shown in Fig. 6 for the sphere.

For the same relative thickness the losses are proportional to the length of the edge, like with the spherical form.

Lastly, the curves for the cylindrical furnace in Fig. 4 are not directly comparable with the others, because they are only for one unit length of a supposedly infinitely long cylinder, and only for the cylindrical part. They must be multiplied by the length of the cylindrical part and the heat loss at the two ends must be added. Even then there is a slight error at the circular corners, as the results in these tables refer only to a cylinder whose outside and inside axial lengths are the same as shown in Fig. 2. They are, therefore, strictly applicable only to long cylinders and do not include the flat ends. They are correct, however, for comparing different cylinders with each other.

The dotted and full curves of Fig. 4 show that the approximate formula is much more nearly correct in this case, and it has the same general character. Not only are the actual differences less, but the percentage differences are also less. Up to a thickness equal to the diameter, the errors in using the approximate formula are within 10 per cent.

That the loss is the same for any given relative thickness, l/d , is well shown in Fig. 8, which corresponds with Figs. 5 and 7, and in which the thickness merely increases with the diameter. These, however, should not be compared directly with those in Figs. 5 and 7, because they are only for one unit of length; the smaller one, therefore, is a cylinder whose length is equal to its diameter, a so-called square cylinder, because both are unity; while the largest one is four units in diameter, but only one unit long, and represents, therefore, a mere flat ring.

In the comparisons shown graphically in Figs. 5, 6 and 7, it should be remembered that a thick wall must be increased very greatly to make it appreciably better; hence, those shown with very thick walls would be very nearly as good with a greatly diminished thickness, and should, therefore, be considered as extreme cases cited to illustrate the laws, and not as giving the best proportions to be used in practice. Instead of using such extremely thick walls, one would naturally sacrifice a greater loss of heat.

[Since the paper was presented Mr. Hering has noticed the following simplification of the correct formula for the spherical and the cubical types, which avoids the square root calculations. For complete spheres the outside and inside surfaces S and s may be replaced by their values in terms of the respective diameters, D and d , the larger one, D , being equal to $d + 2l$ and is therefore easily measured or calculated. It can then be shown that the quantity $\sqrt{Ss}$ is equal to πDd , hence the correct formula becomes simply

$$C = \frac{\pi Dd}{l} \quad (12)$$

which is as simple as could be desired. Similarly for a cubical furnace the correct formula can be reduced to

$$C = \frac{6Dd}{l} \quad (13)$$

in which D is the outside edge and is equal to $d + 2l$. For any one side it would, of course, be $1/6$ of this or

$$C = \frac{Dd}{l} \quad (14)$$

which therefore is the correct formula for such frustrums as constitute the sides of a cube.]

Mr. Hering's paper elicited quite an extended discussion. Mr. Bennie spoke of the possibility of raising the efficiency of an electric furnace by surrounding it with a gas envelope in order to reduce the heat loss from the inside of the furnace to the outside; this is practical because heat generated from gas is cheaper than heat generated electrically. Dr. Richards pointed out that the greatest need now is to determine such constants as heat conductivity, etc. Prof. Landis referred to the valuable old determinations of Peclet which appear to be almost forgotten now. Messrs. Carrier, Hibard, Lidbury and Parker also spoke.

Intermittent Electrochemical Load for Central Stations.

The last subject on the program was a general discussion on the possibility of using electrochemical processes at times of low load of central stations, so as to equalize the load curve.

The subject was introduced by some informal remarks of Mr. ELMER A. SPERRY, of New York City. In a recent conference between central-station men and electrochemists he had noted what appeared to him like an undertone of disappointment on the part of the central-station proprietors as to the price they can get for power for electrochemical and metallurgical work. Mr. Sperry referred to a large 50,000-hp electrochemical works (a calcium cyanamide plant) now being erected at Niagara Falls, and claimed that power in large quantities can now be bought on the Canadian side of Niagara for \$12 per horse-power-year, and perhaps even less, down to \$10. That there is a practical possibility of combining electrochemical work with an ordinary central-station load is proven by a certain plant in Maine which has now been successful for about three years. What is needed are intermittent electrochemical processes, and Mr. Sperry referred to a recent chlorate process which is essentially intermittent. Progress in this whole field is possible only by continual agitation. Electrochemists should acquire the habit of thinking about intermittent processes while central-station men should consider what they can do in the line of price.

While Mr. Sperry represented the electrochemical engineers, the next paper, by Mr. JOHN MEYER, of the Philadelphia Edison Company, represented the central-station side of the question. In the absence of Mr. Meyer it was read by Mr. Graves, of the Brooklyn Edison Co.

Mr. Meyer pointed out that the tendency of the times is in the direction of specializing. Special effort in any one direction results in approaching closely to perfection in any development. This is no less true in the electrochemical and the central-station industry than in other lines of business. If it were possible to eliminate from any process all of the factors incidental to the production, such as, for instance, the supply of current, then it is fair to assume that the maximum effort could be applied to the actual process. All things being equal, there is then every incentive for co-operation between the electrochemist and the central station even to the extent of the location of the electrochemical plant with reference to the central station and hours of use of the current.

With the rapidly increasing demand in this country for many electrochemical products, as is evidenced by the importations of some of them, it would appear important, if not absolutely essential, to develop such industries here and to encourage relations between the central station and such industries at this time.

This is particularly true in the matter of development, wherein the one hindrance is the large immediate investment in order that the experiment may be conducted. Considering then that the experimental load can be so adjusted as to fill valleys which exist consequent to the conditions of the central-station load, there is then the possibility of obtaining a low rate depending upon local conditions which, however, would be mutually satisfactory to both parties concerned and which would help to develop the industry.

As a matter of fact, the majority of the industries started under circumstances where the service supply of the central station could have been used to advantage.

The maximum possible output of any plant *cannot* be maintained continuously. The actual output is a certain percentage of the maximum and may be considered as the average. The ratio between the maximum and the average may be expressed in terms of load factor as illustrated in the following example: If a plant having a maximum capacity of 100 units per day, and the average represents 60 units, then the load factor may be represented as 60 per cent, indicating that the average output was 60 per cent of the maximum possible. If the current

required to perform this operation is in direct proportion to the output of the product, then in the example stated above it is fair to say that, although the maximum may be required at intervals, the average load will only represent 60 per cent of this maximum. Applying this principle to the rate of \$30 per horse-power per annum of the capacity, because of the average load being but 60 per cent of this capacity, the cost of current becomes actually \$50 per horse-power per annum.

This question of load factor is one of importance and has not been fully appreciated by the electrochemical industries. The actual load factor of electrometallurgical plants in France varies from 50 per cent to 60 per cent based upon a 24-hour 365-day year. In other words the cost per horse-power is not the actual cost divided by 365 times 24, but it is a figure which is obtained by multiplying the equivalent 8760 hours by the load factor in percentage and this resulting figure divided into the annual cost per horse-power will produce the actual cost per horse-power-hour.

Mr. Meyer then pointed out that the matter of location of an electrochemical plant is materially affected by facilities for obtaining the raw material or of the disposal of the finished product. For instance, the ideal location of a plant, other things considered equal, would be such that the raw material may be obtained from the immediate neighborhood of the plant and the finished by-products disposed of also near to the plant. "In a recent investigation of contemplated electric furnace plant the central station offered reasonably low rates for an experimental plant of small capacity, holding out as an inducement, which has been admitted to be equitable, a reasonably lower rate in the event of the furnaces proving satisfactory, and the furnace capacity increased to such an extent as to eliminate all of the oil furnaces now in use. There is every evidence that if this particular installation proves satisfactory a great many similar furnaces will be installed in various industries.

"In another instance a small arc furnace having a capacity of 20 kw has been installed for the purpose of demonstrating the production of nitrogen compound with the electric furnace. The current for the operation of this furnace is purchased from the central station. Upon completion of this demonstration a series of furnaces of considerably larger capacity will be installed."

Mr. Meyer finally referred to such electric furnace processes which, like the carborundum process, work necessarily intermittently. Such processes would be ideal for operation from central stations. Industries of such kind should locate chiefly at such points where any by-products could be utilized and easily sold. Such considerations may be more important than the cost of power.

The two papers of Mr. Sperry and Mr. Meyer elicited an extended and at times quite animated discussion. While hardly any tangible result was reached, the discussion certainly helped to clear the views on the subject.

It was opened by President Acheson, who explained that the carborundum process, as carried out at Niagara Falls, required 36 hours, so that it would not directly fit the requirements of central-station load. But if a plant used two furnaces, one being started 24 hours after the other, then it could always be so arranged that at times of peak load of the central station only one furnace would be working.

Mr. Edward R. Taylor said that his own carbon bisulphide furnace could be worked intermittently, but not as well as continuously. It would not do to shut the current off continuously, but it might be reduced to such an extent as to maintain the temperature in the furnace without furnishing any energy for the chemical reaction. Of course, this would be uneconomical to a certain extent.

Mr. Carl Hering pointed out that for the reasons just given by Mr. Taylor, it is very important to know the loss of heat through the furnace walls of an electric furnace, since this loss

represents the electric energy which must be supplied to the furnace at the non-working period, as sketched by Mr. Taylor.

Mr. W. F. Wells, of the Brooklyn Edison Co., thought that arrangements were quite possible by which current could be furnished from the central station to electrochemical works continuously during the greater portion of the year; during another portion of the year current could be furnished continuously except on Saturday nights; and during another very short period, which would be not more than a month and a half, current could be furnished continuously, with the exception of a one-hour peak. It is a fact that 25 per cent of the capacity of a large number of central stations is used only during 100 hours per year. To find a use for these 25 per cent of capacity during the balance of more than 8,000 hours would be very important.

Mr. Lawrence Addicks thought that to buy current from a central station would not be attractive to the copper refiners, since they are able to produce very cheap power themselves with their excellent load factor. Moreover, the copper refining process is exceedingly sensitive with respect to changes of conditions.

Mr. C. F. Carrier, Jr., had figured out a scheme for an electrolytic sodium plant, but found that when he would get the power cheap enough for his purpose the central station would make no money, and that on the other hand he could make no profit with the sodium if the central stations made money with their power. It seemed that the only possibility of combining profitably electrochemical work with central-station load would be for the central stations to undertake the electrochemical work themselves.

Mr. F. A. J. FitzGerald had made tests with an induction furnace to find the amount of power required to simply keep the temperature of the steel constant without working. This was not less than one-third the normal power of operation.

Mr. Hy. D. Hibbard thought that the central stations should endeavor to extend the use of electricity for simple power purposes, like grinding, in chemical and metallurgical works.

Mr. C. A. Graves, of the Brooklyn Edison Co., explained that electric central stations now supply power for refrigerating purposes. He also emphasized the great reliability of electricity supply from large central stations; they are quite willing to make contracts involving large payments of damages in case of failure of supply even for minutes only.

Mr. J. M. Kebbe, of the Brooklyn Edison Co., emphasized that in many cases the greater cheapness of water-power may be more than counterbalanced by the better shipping facilities, the nearer market, the cheaper labor, etc., usually found near large central stations. He and Dr. Richards referred to the successful working of the Girod steel furnace in a Swiss city, where energy is bought from the central station at a reduced rate (see page 452 of our November issue).

Mr. G. Breed, of Philadelphia, referred to the conditions of some power plants outside of New York State. Mr. Kohn asked for exact figures of rates. The fixation of rates by Public Service Commissions was also referred to.

Mr. Bennie said the power companies of Niagara Falls had paid the greatest attention to the subject of power factor and had found no solution. Mr. Addicks thought that the importance of the power cost is sometimes overrated; in copper refining it is from 20 to 25 per cent of the total cost; and a little saving in power may easily be outbalanced by other factors.

Dr. Richards thought there was certainly a field for the use of electric power from central stations for the operation of relatively small electric furnaces intermittently in brass and steel foundries and for the simple melting of metals.

Mr. Edward R. Taylor, who represents the Society on the Commission for the Conservation of Our Natural Resources, then gave an outline of the work of this commission.

On motion of Mr. Hering a vote of thanks was tendered to all who had made the meeting successful. Adjournment followed.

The attendance was beyond 200. In the following we give an alphabetical list of those names contained in the last printed registry list:

Edward G. Acheson, Niagara Falls, N. Y.; Charles E. Acker, New York City; Lawrence Addicks, Elizabeth, N. J.; Mr. and Mrs. W. A. Arison, Niagara Falls, N. Y.; L. Beckland, Yonkers, N. Y.; W. D. Bancroft, Ithaca, N. Y.; Harry Barker, New York City; Walker Bowman, New York City; Charles E. Bradley, New York City; F. E. Breitbut, New York City; A. A. Breneman, New York City; C. F. Burgess, Madison, Wis.; C. F. Carter, N. J.; H. B. Carveth, Niagara Falls, N. Y.; Charles F. Chandler, New York City; H. B. Colo, New York City; Edward A. Colby, Newark, N. J.; F. D. Crane, New York City; J. S. Crider, Cleveland, Ohio; E. B. Crocker, New York City; Mrs. C. H. Crotch, Savannah, Ga.; T. S. Crossman, New York City; R. W. Curtis, New York City; Alerton D. Cushman, New York City; Zoltan de Havath, New York City; William Dreyfus, New York City; C. A. Doremus, New York City; G. Droegbe, Brooklyn, N. Y.; Orrin E. Dunlap, Niagara Falls, N. Y.; E. Durant, New York City; Thomas A. Edison, Orange, N. J.; A. H. Elliott, New York City; W. E. Estabrooke, New York City; Irwin H. Fenn, New York City; Mr. and Mrs. John H. Finley, New York City; L. H. Friedburg, New York City; R. H. Gaines, New York City; A. E. Gibbs, Wyandotte, Mich.; C. P. Goepel, New York City; J. H. Goodwin, East Orange, N. J.; W. L. Goodwin, Kingston, Ont., Can.; Mr. and Mrs. C. A. Graves, Brooklyn, N. Y.; H. C. Griffin, New York City; Morton L. Griffin, Springfield, Mass.; L. F. Guttman, New York City; Charles M. Hall, Niagara Falls, N. Y.; W. J. Hammer, New York City; W. A. Hamor, New York City; J. L. Harper, Niagara Falls, N. Y.; Jacob Hasslacher, New York City; Carl Hering, Philadelphia, Pa.; Henry D. Hibbard, Plainfield, N. J.; J. F. Hinkle, Brooklyn, N. Y.; B. H. Hite, Morgantown, W. Va.; Walter E. Holland, Orange, N. J.; Mr. and Mrs. Henry Idoway, Brookline, Mass.; J. C. Howell, New York City; George A. Hulett, Princeton, N. J.; Walter R. Ingalls, New York City; Woolsey McA. Johnson, Hartford, Conn.; Mr. and Mrs. G. M. Kebbe, Brooklyn, N. Y.; A. A. Knudson, New York City; Wallace G. Levison, Brooklyn, N. Y.; LeBonitlier, New York City; Wallace G. Levison, Brooklyn, N. Y.; F. L. Lichy, Niagara Falls, N. Y.; A. T. Lincoln, Troy, N. Y.; C. F. Lindsay, Schenectady, N. Y.; Carl H. Lips, Brooklyn, N. Y.; Morris Loeb, New York City; C. C. Lundey, New York City; W. L. Madden, Newark, N. J.; C. O. Mallouss, New York City; V. J. McMurtrie, New York City; Mr. and Mrs. H. R. Moody, New York City; G. W. Morden, Toronto, Can.; L. P. Morgan, Philadelphia, Pa.; Paul F. Mottelay, New York City; Charles W. Moulton, Poughkeepsie, N. Y.; W. H. Nichols, New York City; Nathaniel Nodell, New York City; William L. Nodell, New York City; R. J. Nunn, Savannah, Ga.; Thomas F. O'Keefe, New York City; John C. Parker, Rochester, N. Y.; H. E. Patten, Washington, D. C.; H. Philip, Perth Amboy, N. J.; W. H. Prager, New York City; B. E. F. Rhodin, Sault Ste. Marie, Can.; J. W. Richards, Camden, N. J.; I. L. Roberts, Lockport, N. Y.; E. F. Roher, New York City; A. J. Rossi, New York City; S. S. Sadler, Philadelphia, Pa.; S. E. Saunders, Niagara Falls, N. Y.; G. P. Scholl, New York City; F. F. Schuetz, New York City; C. H. Sharp, New York City; William Acheson Smith, Niagara Falls, N. Y.; J. J. Lorenz Sporer, New York City; Miss L. Statham, Mechanicsville, N. Y.; Noel Statham, Mechanicsville, N. Y.; R. Stevenson, New York City; C. C. Stirling, Hartford, Conn.; Walter T. Taggart, Philadelphia, Pa.; Mr. and Mrs. E. Taylor, Penn. Can., Edinburg, Pa.; E. Taylor, New York City; J. E. Teckle, New York City; B. F. Thomas, Chattanooga, Tenn.; Maximilian Toch, New York City; F. J. Tone, Niagara Falls, N. Y.; Mr. and Mrs. C. P. Townsend, Washington, D. C.; S. A. Tucker, New York City; F. Varley, New York City; L. D. Vance, Detroit, Mich.; R. von Foregger, New York City; R. von Alois von Isakovics, Monticello, N. Y.; W. H. Walker, Boston, Mass.; W. D. Weaver, New York City; Uley Wedge, Philadelphia, Pa.; W. F. Wells, Brooklyn, N. Y.; E. Weston, Newark, N. J.; W. A. Whitaker, New York City; Mrs. J. W. Wier, New York City; F. B. Wier, C. H. Wiechman, Brooklyn, N. Y.; H. W. Wiley, Washington, D. C.; H. Zimmerli, Hamburg, Germany; J. A. Yuncck, South Orange, N. J.; F. Wohlmann, Newark, N. J.

from the humiliation of slavery. Natural, and moral, and religious knowledge are of one family; and happy is that country, and great its strength, where they dwell together in union."

We have been passing, not through a period of war, but a period of national distrust and depression and are emerging freed from many entanglements which have threatened the body politic. In the midst of this distrust of the future our attention has been called to the vast natural resources which abound on all sides. But we have also been warned of the wasteful misuse of these, and a call has gone forth from the chief of the nation which has resulted in the formation of a National Conservation Commission, whose duty it shall be to secure the wisest utilization of our wealth, with due regard to our posterity. While the national government instigated this movement, the States have now individually given their hearty approval and co-operation.

While the nations of Europe long ago appreciated the importance of chemistry as the basis of their pursuit of either agriculture or of manufactures, we have been tardy in recognizing our needs in this direction. It is only within the past quarter of a century that our universities and technical schools have been equipped with adequate laboratories where chemistry and the sister science physics could be studied as they should be. Not until the progress in electricity created a demand for instruction, which our institutions could not ignore, did we awake to the necessity of providing our young men the educational advantages needful to their life work.

Our national chemical society, founded in 1876, had in its first years a precarious existence. It required the most patient and persistent labor of its organizers to carry it through to the wide influence which it is now exerting and which it is now further extending by developing still wider fields of usefulness.

We have been forgetful of our opportunities, of the solid foundations upon which this nation was built, of the virility of the men who took upon themselves the task of conquering nature in a wilderness.

In their foresight they founded the Philadelphia Chemical Society in the year 1792. It was the first society of its kind in the world. Priestley was a member. It was the custom that there should be an annual oration. Such a one was delivered before the society and ordered published on April 11, 1798. Mr. Thomas B. Smith chose as his title "A Sketch of the Revolutions in Chemistry." His peroration is so permeated with inspiring thoughts, which apply so well to our present needs, sound such an optimistic bugle call, that we venture to quote the closing paragraphs, that we be reminded of our birthright:

"Living as we do in a new, extensive and unexplored country, separated by an immense ocean from all other civilized nations, we must feel ourselves deeply interested in a knowledge of its mineral productions and this can only be arrived at through the medium of chemistry. As far as our very limited knowledge has yet gone, we have every reason to believe that Nature has been far from bestowing her blessings with a parsimonious hand. Abounding as it does with the richest ores of the most valuable metals, we should be committing a crime of the blackest dye were we through *wilful ignorance* to trample under our feet these invaluable gifts of the Creator.

"The only true basis on which the independence of our country can rest are agriculture and manufactures. To the promotion of these nothing tends in a higher degree than chemistry. It is this science which teaches man how to correct the bad qualities of the land he cultivates by a proper application of the various species of manure, and it is by means of a knowledge of this science that he is enabled to pursue the metals through all the various forms they are put on in the earth, separate them from substances which render them useless, and at length manufacture them into the various forms for use and ornament in which we see them. If such are the effects of chemistry, how much should the wish for its promotion be

The Promotion of Science the True Means to the Re-establishment of National Prosperity.

By CHARLES A. DOREMUS, M.D., PH.D.

The closing years of the eighteenth century witnessed our people endeavoring to reap the fruits of their struggle for independence in building up the new nation which they had founded. War continued to devastate Europe, and it was difficult to foresee which nation would in the end hold the supremacy. It was during this trying period at the beginning of the nineteenth century that Sir Humphrey Davy, in a public lecture, called attention to the cultivation of the sciences as follows:

"Science, for its progression, requires patronage; but it must be a patronage bestowed, a patronage received with dignity. It must be preserved independent. It can bear no fetters; not even the fetters of gold, and, least of all, those fetters in which ignorance or selfishness may attempt to shackle it.

"And there is no country which ought so much to glory in its progress, which is so much interested in its success, as this happy island. Science has been a prime cause of creating for us the inexhaustible wealth of manufactures, and it is by science that it must be preserved and extended. We are interested as a commercial people. We are interested as a free people. The age of glory of a nation is likewise the age of its security. The same dignified feeling which urges men to endeavor to gain a dominion over nature will preserve them

excited in the breast of every American! It is to a general diffusion of a knowledge of this science, next to the virtue of our countrymen, that we are to look for the firm establishment of our independence. And may your endeavors, gentlemen, in this cause entitle you to the gratitude of your fellow citizens."

Transportations of Liquids.

By OSKAR NAGEL, PH.D.

For the transportation of liquids a large number of appliances, such as injectors, syphons, eductors, air-jet lifts, monte-jus pumps, etc., are on the market. According to the nature of the liquid handled, these apparatus are made of iron, copper, lead, bronze, hard rubber or stoneware. Enamel is frequently used as coating.

Acid-proof cast iron may be made according to the following analysis:

	A.	B.	C.
	DARK GRAY.	LIGHT GRAY.	MIXED.
Silicon	3.5	1.5	0.7
Manganese	0.5	0.4	0.2 to 0.3
Phosphorus	0.2	0.2	0.2
Total carbon.....	3.8	3.5	3.5

All three brands, A, B, C, should be free from sulphur. To get the best results, A, B and C should be mixed in the proportions of 2:1:1.

Injectors.—The Koerting universal double-tube injector,

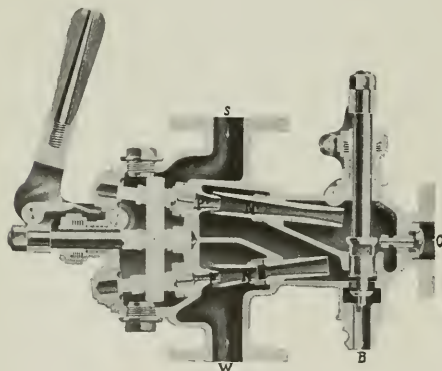


FIG. 1.—INJECTOR.

shown in Fig. 1, is extensively used for transporting water to the boiler.

B is the discharge; N the lower water nut; N₁ the upper water nut; O the overflow valve; P the lower steam nozzle; P₁ the upper steam nozzle; S the steam supply; W the suction.

This injector is a combination of two jets. The lower jet is proportioned for extreme temperatures, and for quick and strong action, which includes maximum high suction. The discharge is into the upper jet where the water receives the additional strong impulse to carry it into the boiler. The pressure and volume from the lower jet corresponds to the steam pressure, and this is as it should be to answer the requirements of the upper or forcing jet. The varying volume insures the proper working at high steam pressure, as well as at low, and increased pressure admits increased high temperature.

Universal Syphons or Steam Jet Pumps.—These apparatus are used for moving water or other liquids, where durability, low cost and simplicity of manipulation are of importance or where an increase of temperature is beneficial. They are made of brass or iron, with brass nozzles.

These syphons are advantageously used for lifting bleaching liquor, milk of lime, water, pulp, sugar juice, molasses, chemicals, etc. The extreme simplicity of the apparatus and certainty of operation at all times are evident advantages. In most applications where it is necessary to heat the liquid the cost of elevating the liquid may be considered to be almost nothing.

Stoppages in suction pipes, strainer or in the apparatus are

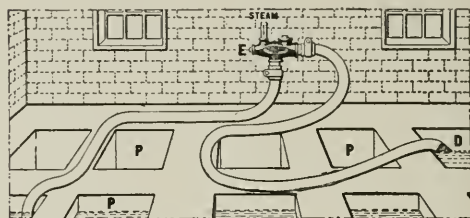


FIG. 2.—SYPHON FOR TRANSFERRING LIQUID FROM PITS.

promptly cleared by providing a shut-off in the discharge pipe, which when closed will cause the steam to blow back and clear the obstruction.

Fig. 2 shows an application of these syphons for transferring liquids from pits, in tanneries or chemical works. D is the discharge, E the syphon and P the pits.

The most extended application of syphons is found in such chemical industries where the liquids need not only to be elevated and moved, but also heated. They may also be used in

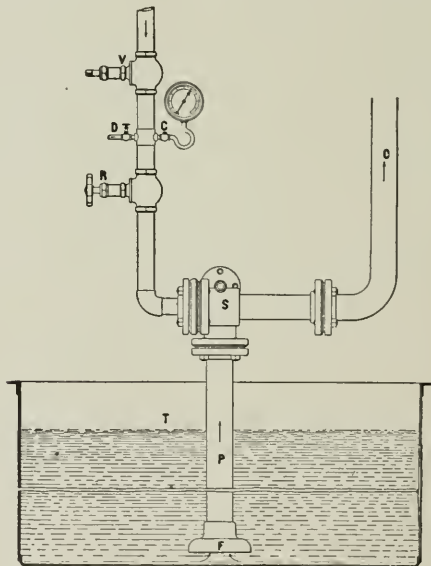


FIG. 3.—LEAD SYPHON.

place of centrifugal pumps for circulating lyes and extracts and a slightly changed construction is successfully applied for artesian wells.

For the lifting of acids and other substances that have a corroding effect upon brass and iron the syphons are made of lead, stoneware or porcelain.

Fig. 3 shows the arrangement of a lead syphon. C is the

check valve, D the drain, F the strainer, O the delivery pipe, P the suction pipe, R the stop valve, S the syphon, T the tank, V another stop valve.

No lead burning is required in making connection to the syphon, as the lead pipe is flanged through and smooth and is fitted to the syphon by means of suitable counter flanges. The flanges must be bolted perfectly tight and firm so that no leaks occur. It is generally recommended to fix the syphon a foot or two above the liquid, so that the liquid has to be drawn up and the syphon empties itself when not in operation.

The steam pipe should be blown out with high-pressure steam before connection is made to the syphon. When there are lumps or floating particles in the supply a strainer should be attached to the suction pipe. The syphon works best in any given case at a certain steam pressure, which has to be found out by throttling the steam. Therefore, when such a syphon is installed it should be arranged as shown in the cut.

Valve V is throttled to the most favorable steam pressure and locked in that position. Valve R is used for operating the syphon only. Before starting the syphon valve D should

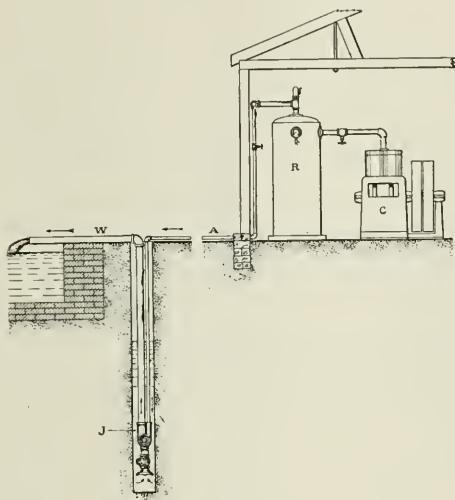


FIG. 4.—AIR-JET LIFT.

be opened in order to draw off any condensed liquid. Care has to be taken that no traps occur in the delivery pipe and that the suction pipe is perfectly air-tight.

Air-jet lifts are simple and efficient means for lifting liquids by means of compressed air, especially in places where piston pumps or steam jets cannot be used. The working of the air-jet lifts is as follows: Air is pressed into the lower end of a submerged pipe. The air mixes with the water inside the air-jet lift and forms a mixture of air and water which is lighter in specific gravity than water alone. The column, consisting of air and water, is therefore driven upwards. In other words, the apparatus works through the difference of specific weight of the two columns.

The arrangement, shown in Fig. 4, consists of the discharge pipe W, the air-pressure pipe A, and the apparatus proper J. The discharge pipe may be any kind of pipe which discharges the water freely so that the water can get rid of the air.

The apparatus is so constructed that the air is distributed as uniformly as possible over the area of the water discharge pipe. In cases where the machine is put in a well there is usually provided a strainer on the inlet of the apparatus. In cases where the water is carried to the machine by means of

a pipe, the connection of the apparatus is made by means of an elbow. The discharge pipe and the air pipe are placed as close together as possible, so that the apparatus can be installed in narrow wells.

The apparatus is to be installed as deep under the level of the liquid as to correspond to the height of lift. To operate the apparatus it is only necessary to open the valve in the air pressure line, the quantity of liquid being regulated by varying the quantity of compressed air.

Further advantages are that it occupies little space and can be easily erected in sulphuric acid plants (for which purpose it is made of lead, stoneware, hard rubber or porcelain) at the foot of the tower in ordinary sewer pipes, which are sunk in the ground according to the height of discharge. The apparatus throws the acid directly into the interior of the Glover and Gay-Lussac towers by letting the discharge pipes extend through the top of the towers. By arranging a plate inside, against which the acid is forced, the ordinary distributors on top of the tower are eliminated in a satisfactory manner. The acid air-lift uses less compressed air than the acid egg and can be made of suitable material. For lifting sulphuric acid it is made of lead; for lifting concentrated acid, of cast iron; for nitrate acid, of stoneware.

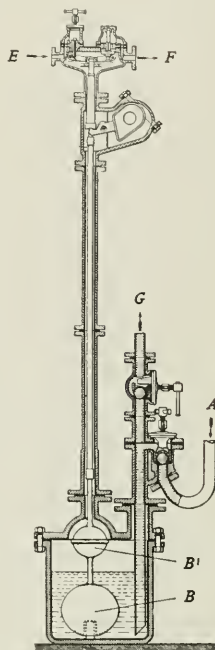


FIG. 5.—AUTOMATIC MONTEJUS.

Automatic Montejus.—In this apparatus compressed air is also used for lifting a liquid. It is extensively applied in acid works, especially in the form shown in Fig. 5. In this type the liquid has run to the machine by gravity, entering at A through a check valve. Let us assume that the tank is empty and that the full weight of the lower float B keeps the exhaust valve F open, so that the liquid can freely run into the tank. The liquid rapidly covers the lower float B, but the buoyancy thus started is not sufficient to open the air valve E. This is accomplished when the liquid reaches the upper float B'. The combined buoyancy of both floats shuts the air exhaust valve F and opens the compressed air inlet E, the liquid being now discharged through the check valve and the discharge pipe G.

The level of the liquid drops now rapidly below the float B', but the weight thus exerted is not yet sufficient to shut the compressed air inlet valve. This is accomplished after the liquid has dropped below float B, the weight of the floats being now sufficient to shut the air inlet valve and to open the air relief valve. The conditions are now again the same as at start and the operation is repeated. These acid eggs are made in the following styles, entirely of cast iron, lead lined or entirely of copper.

Water Jet Eductors.—This apparatus, which, like the injectors and syphons shown, is built by the Schutte & Koerting Co., Philadelphia, is used to lift liquid by means of water under high pressure. It is especially useful where high-pressure water is at disposal and in places where, on account of in-

sufficient space, a pump cannot be installed. The actuating water can either be taken from a local source, such as water works, a natural water source, etc., or can be supplied by pressure pumps.

The motive power is pressure water passing through the apparatus with great velocity. This creates a vacuum and sucks in the water to be lifted, which is then carried along with the pressure water to the discharge outlet. Fig. 6 illustrates one of these eductors.

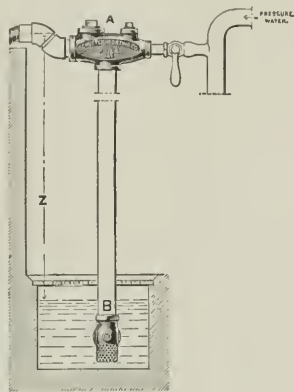


FIG. 6.—WATER-JET EDUCTOR.

trates one of these eductors. A is the eductor, Z is the height of lift.

These pumps have the following advantages: They have no valves or any moving parts; they are not subject to wear and tear and cannot get out of order; they are noiseless in operation, and they are the simplest and most convenient apparatus when high-pressure water is at disposal.

SYNOPSIS OF PERIODICAL LITERATURE

Furnace Construction.

Fire Brick.—The old practice of cutting bricks to shape for fitting into the walls of furnaces has been done away with in most cases by the use of special shapes of fire bricks. In an article on the "Lining of Heating and Melting Furnaces," in the Oct. 15 number of *Iron Age*, Ulrich Peters describes the special shapes in most common use and their application to special cases. A number of formulas for the design of such special forms as arches and circles to conform to the special shapes of bricks are given of value to the bricklayer.

Basic Refractories.—The use of basic refractory materials is at present very much limited. This may in part be due to lack of knowledge of their durability in special cases, it being the point particularly brought out in the Oct. 24 issue of the *Engineering and Mining Journal* in an article by F. T. Havard. Magnesite bricks are recommended for the lining of reverberatory copper furnaces in place of the ordinary fire-clay brick commonly used for this purpose. The brick resists very well the corrosion due to the slags used, but will not withstand the scouring action of a moving metallic bath. At high temperatures they become soft and wear away rapidly. In the lead reverberatory all brickwork coming in contact with the metal or slag should be magnesite or chromite. This latter material is used almost exclusively for the walls and hearths of cupelling and test furnaces. Chromite is really the only material that resists the corroding influences at work in the reverberatory furnaces used for the reduction of antimony. But little attention has been given to the use of the two materials mentioned above

for the lining of crucibles of copper blast furnaces. As these furnaces are always water-cooled, magnesite is well adapted for this purpose, the cooling of the brick being sufficient protection against their disintegration. Magnesite bricks should always be laid in a mortar composed of magnesite and tar, water never entering into its composition.

Open-Hearth Port.—A new water-cooled port for open-hearth furnaces is described, with drawings, in the Oct. 15 number of *Iron Age*. It consists of a series of 2½-in. iron pipes side by side in arch form brought in through the end wall of the furnace. The pipes are protected by special hollow bricks. The pipes all end in a bronze casting forming the outside face of the arch. To keep this in place and also to maintain the sides of the port a special water-cooled skewback casting of bronze is used. The whole arrangement offers a satisfactory solution of a most difficult problem of maintaining the sides and top of the open-hearth port.

Iron and Steel.

Dry Blast.—A most complete description of an actual installation of the Gayley dry-blast system was presented to the American Institute of Mining Engineers at the Chattanooga meeting by Mr. E. B. Cooke, furnace manager of the Warwick furnaces at Pottstown, Pa., where a large installation of this system was recently made. These furnaces are merchant furnaces and consequently are guided in their running by the order book. It has always been a question as to the advantages to be gained from the application of this system to such a furnace, a question solved most completely by this interesting analysis. The paper has been reprinted in *Iron Age* of Oct. 1 and *Engineering and Mining Journal* of Oct. 24. The furnace plant consists of two stacks, one about 70 ft. high and the other 100 ft. high, the system being used in both of them. The refrigerating plant consists of five units with a total refrigerating capacity of 875 tons per day, and requires 1100 hp. This multiplicity of units makes the plant well able to economically take care of the varying conditions represented in the extremes of winter and summer. In winter only one unit is required. Allowing 4.5 tons of air per ton of iron made, and the capacity of the plant being 720 tons of iron a day, 135 tons of air per hour must pass through the freezing system. In the case of the higher stack, a furnace with 22-ft. bosh and 15-ft. crucible, the use of the dry blast (original moisture in the air averaging 4.5 grains per cubic foot, dried air carrying only 1.5 grains per cubic foot) resulted in the following most marked advantages: A reduction of speed of the blowing engines of 10 per cent; an increase in burden of 5 per cent, and an increase in the silicon content of the iron from 2 to 2.75 per cent. On the smaller furnace the capacity was increased from 1400 tons of iron a week to 1700 tons, the fuel consumption at the same time being reduced from 2200 lb. per ton of iron made to 1900 lb., and all with a blast temperature of 100° lower than previous to the drying. The total cost of drying the air is figured out to be about 10 cents per ton of iron produced, this, of course, representing the maximum of summer running. No extra steam is used for the refrigeration engines, the reduced speed of the blowing engines allowing of more than enough for this purpose. In regard to the explanation of this increased efficiency, that given by Prof. J. W. Richards in his discussion of the same subject before the Mining Engineers some two years ago, seems to be corroborated. (See our Vol. III, page 240.)

Converter Process.—In a most detailed investigation, given in *Metallurgie* for September and October, F. Wüst and L. Laval show that contrary to most published references in the blowing of a basic converter 25 per cent of the phosphorus is removed before all the carbon is burned out. The loss in iron consequent to the removal of 6.7 to 7.8 per cent of impurities amounted to 8.2 and 10.7 per cent, of which 2.7 and 4.7 per cent were burnt during the after blow in order to remove the last tenth per cent of phosphorus. The combustion of this element produces a high temperature and the affinity of iron

for oxygen becomes greater at a high temperature than that of phosphorus. The loss of iron can be diminished by cooling the bath during the after-blow by scrap additions or lime-ore briquets. It is more economical to remove phosphorus in the open-hearth furnace when this element is present in considerable quantities as it can be concentrated in a phosphorus-rich, iron-free slag suitable for use as a fertilizer. The use of dry air increases the soundness of the castings. The use of enriched or of preheated air is not recommended, because of the final high temperature attained. The time of blowing is shortened, but the loss of iron is very high.

Phosphor Steels.—J. De Kryloff, in *Revue de Metallurgie* of last July, gives some properties of some new phosphor steels. Phosphorus in steel causes the formation of a granular structure and great brittleness, both being due to the phosphide of iron formed in the steel. Annealing of these steels causes a marked increase in elongation, in one case of from 1 per cent originally to 14 per cent after quenching and annealing to 750° to 780°. A uniform structure of the steel could only be obtained when the phosphorus content is below 0.07 per cent, a larger proportion preventing the even formation of perlite and cementite.

Gases in Steel.—*Revue de Metallurgie* for July and August contains each an article by G. Belloc on the occlusion of gases by steel. A basic open-hearth steel of the following composition: carbon, 0.12 per cent; silicon, 0.03; sulphur, 0.02; phosphorus, 0.018, and manganese, 0.36, was investigated, gas samples being collected at various intervals of heating and analyses made of them. The disengagement of gas begins between 150° and 400°. The ratio of the volume of the temperature shows a minimum at 200°, a maximum at 300°, a maximum at A_2 between 500° and 550°. A minimum value of this ratio is again found at A_3 , 710°. A_4 , 790°, again shows a maximum somewhat lower than those previously reached. Alpha iron gives up the gas slowly, the amount evolved, however, increasing with the temperature. The transformation of alpha iron into beta iron is marked by an abundant evolution of gas. The disengagement begins again with the transformation of beta into gamma iron, reaching a maximum toward the end of the transformation, falls off and then increases slightly with the temperature in gamma iron. The transformation of carbon as cementite into temper carbon has no influence on the occlusion of gas if the carbon content is 0.12 per cent. The gas evolved consists of a mixture of CO_2 , CO, H and N. CO_2 is disengaged first and forms almost the whole of the gas evolved, but above 550° it begins to be reduced by H. N appears at 550° and persists to the highest temperatures. Above 400° H and CO appear and soon make up almost the total bulk of the gas evolved. The gas is very irregularly distributed through the pieces investigated. At an average depth many times more gas was evolved than from chips taken from the outer surface or the central core. In a special nickel steel, containing 45 per cent nickel and 0.15 per cent carbon, the gas evolved measured $3\frac{1}{2}$ times the volume of the chips taken. Evolution started at 480°. At 500° the gas consisted almost entirely of CO and H. The evolution of N started at 600° and at 960° made up 14 per cent of the gas evolved. In the case of a wire drawn from this same steel the gas evolved measured 10 times the volume of the wire taken.

Manganese Steel for Rails.—Mr. H. M. Steward contributed to *Engineering News* of Oct. 9 a paper on the "use of cast manganese steel rails on curves of the Boston Elevated Railway." The average life of a Bessemer steel rail of 0.40 carbon on a certain curve was 60 days. A rail cast of manganese steel has been in service on the same curve for six years, three months and seven days and is still in use. The average traffic over the Bessemer rail was 1000 cars a day, or 36,000 tons. The traffic over the manganese-steel rail has averaged 1700 cars a day, or 62,000 tons. The cost of maintenance of the manganese-steel rail for this six-year period has been

\$7.01, against the cost of maintenance of the Bessemer rails for the same time of \$44.15. It is not probable that manganese-steel rails will be used on tangents. Their great ductility allows of the ends being pounded down much more rapidly than the harder carbon-steel rails at present in use. The great difficulty in the production of manganese-steel rail makes it rather expensive, though there is some prospect of one being able to obtain rolled rails of this metal at a much less cost than is now charged for cast ones.

Nickel Steel.—Mr. J. L. Waddell has been communicating to the press for some time past a series of articles on the use of nickel steel for structural purposes and has carried out a large series of large scale purposes in this line. He has recently presented to the American Society of Civil Engineers what he calls a "Summary" of this work, this summary being in the form of a paper of more than 200 pages, published in full in the publications of the society. In it he calculates that nickel steel can be used more economically than carbon steels in all bridge structures over 30-ft. span, the proportion entering into their construction being dependent on the span. For instance, a bridge of 1800-ft. span can be built of nickel steel more cheaply than one of 1600-ft. span made out of ordinary carbon steel. The greatest difficulty in the use of this material is in its handling by the bridge shops. They are not at present equipped to punch and drill it. For beams and shapes a $3\frac{1}{2}$ per cent nickel steel is recommended; for eye-bars and parts not to be punched or cut a $4\frac{1}{2}$ per cent nickel steel. The strength of these steels varies from 47 to 54 tons per square inch. The cost of them averages about $1\frac{1}{2}$ cents a pound higher than ordinary structural steels, but the strength for a given weight is 66 per cent greater than carbon steel.

Copper.

Lake Copper.—Some rather interesting information about Lake copper has been brought out in the case of the Calumet & Hecla Mining Company against the Osceola Copper Company in regard to the grades of "Lake" at present on the market. Calumet refines the highest grades of its copper by the furnace, the lower grades being refined electrolytically and mixed with other of its mined coppers, all being from the Lake region. Osceola, Tamarack and Ahneck, but western cathodes, principally from Boston and Montana, and mix these cathodes in equal proportions with their own product, selling it also as "Best Lake."

Copper Smelter.—In the design and construction of a small copper smelter one is often at a loss for data on which to base the design. In the *Engineering and Mining Journal* of Oct. 31 Mr. Charles C. Christensen fills up a large gap in this information in an article on the "construction of a 100-ton copper smelter." Furnaces of rectangular section smelt per day from 3.25 to 3.75 tons of ore and flux per square foot of tuyere section, this capacity increasing somewhat with the height of the furnace. A furnace should not be over 54 in. wide in any case and a 100-ton furnace not over 40 in. For this capacity and this width the length figures out 96 in. long. The blast required is 260 times the hearth area at the tuyeres in square feet expressed in cubic feet per minute. At a blast pressure of 1 lb. per square inch this would require 43 hp to drive the blower. For sampling a 7 x 10 Blake crusher would require 7 hp, one pair of 24 x 8 rolls 5 hp, one pair of 12 x 12 rolls 3 hp, one sampling machine 3 hp, shafting 2 hp, total about 20 hp. About 15-hp pump capacity is required. The whole plant should be provided with at least 100 hp. The article ends with a set of specifications for the whole plant, the same being used in the erection of one of this capacity.

Mine Waters.—At the Copper Queen Mining Company's Bisbee mines the water from the shallow mines, like the Czar and the Holbrook, in which the ores are mostly oxidized, contain 10 grains of copper per gallon, there being pumped up about 300 gal. per minute. The water from the deeper mines does not carry but a trace of copper. The recovery plant for extracting this copper is described by Mr. H. W. Chittenden in

the *Engineering and Mining Journal*, Oct. 31. The plant consists of a series of troughs built in the form of a rectangle, 78 ft. x 108 ft., there being five vertical tiers on three sides and four tiers on the other. In all there are 1650 ft. of these troughs. They are built double so as to facilitate cleaning without interrupting the precipitating operation. The troughs are 3 ft. wide and 20 in. deep, made of 2-in. plank. Iron in the shape of tin cans, gathered cheaply around Bisbee, is the precipitating agent. The top tiers are cleaned every second day, the lower ones less frequently. Cleaning is done by means of a pressure water jet from a hose. A settling tank at the end of the troughs catches the slime in suspension.

Copper Reverberatory.—Various attempts have been made to equip a copper reverberatory with a regenerator, but most have failed. The old checker systems choke up with dust and soon reduce the force of the draft so much that the furnaces refuse to work. Mr. F. A. Leas describes a new type in the *Engineering and Mining Journal* for Nov. 7. The furnace uses oil for fuel, though the system can be applied to any furnace fired by gas or coal dust. From each end of the furnace a long flue is run, they connecting with a common chimney. A reversing valve at the chimney end allows of one flue being directly connected to the chimney, while the other is open to the air, the whole being done by one operation. The gases on passing out through the flue give up their heat to the walls and enter the chimney at only about 500°, and on reversal the air entering the furnace must pass through this heated flue and abstract the heat from the walls. In general the temperature of the gases entering the furnace vary from 1000° to 400°, depending on the time elapsed since reversal. The capacity of the furnace was increased 50 per cent with no additional fuel consumption.

Copper Converter.—C. Offerhaus gives rather a detailed description of the operation of an Anaconda copper converter in *Engineering and Mining Journal* for Oct. 17. The lining used consists of an Idaho silicious copper ore mixed with slurry from a settling tank around the works. Sixteen tons of this material is required to line the converter, 8 ft. diameter and 12½ ft. long. It is tamped in on a special brick lining by an air tamper. One and one-half hours are required for lining and seven hours for drying the same. The converter is charged with nine tons of 45 per cent matte at a temperature of about 900°. The blowing operation lasts two hours.

Lead.

Choking Up of Lead Furnace.—Trouble is usually experienced in the running of a lead furnace by the choking up of the crucible and lead well. A new method of opening such a crucible and well is to dynamite it, the operation being described in *Engineering and Mining Journal* of Oct. 17 by J. N. Goddard. A cartridge is made of one-seventh of a stick of 50 to 60 per cent dynamite by inserting it into a piece of iron pipe which has been carefully lined with asbestos. The ends are plugged with this same material and an iron plug screwed into one end, the other being screwed into a rod of suitable length to allow insertion into the lead well of the furnace. Enough time elapses before the explosion to allow the man who inserts the cartridge to get out of the road of the splash of lead accompanying the explosion, 10 to 25 seconds. Usually one such shot proves sufficient, though several have been successively used. The damage done to the furnace after firing 50 such shots is hardly noticeable.

Broken Hill Ores.

Concentration.—The Broken Hill ores have always been of interest to our metallurgists. The general method of treatment of these ores is well described in an article by G. W. Williams in the *Engineering and Mining Journal* of Nov. 7. These ores consist of an intimate mixture of galena and blende, carrying 7.5 oz. to 12 oz. of silver per ton, the silver being evenly distributed between the galena and blende. The ore is accompanied by a gangue of rhodonite and garnet sandstone of near the same gravity as the valuable content, causing great

wear on the crushing machinery and considerable loss in the tailings. At times a clean calcite or quartz gangue allows of very clean separation. The ore is, in general, broken by Blaker Gates crushers to 2-in. size, passed over shaking screens, and sent to rolls set to 3 mm, the oversize from the rolls being sent to a differently set roll to avoid excessive sliming. The final roll product passes to jigs, where about 75 per cent of the lead content is extracted in concentrates running 65 per cent lead. The jig tailings pass to Krupp or ball mills, are there crushed to 0.5 mm size and are returned to jigs or tables. The tailings from the jigs or tables pass to the dump, where they are stored to await extraction of their zinc concentrates. Average practice extracts from 63 to 75 per cent of the lead content and 36 to 55 per cent silver.

Aluminium.

New British Aluminium Plant.—*Electrical Engineering*, Nov. 12 (London), contains an illustrated description of a new aluminium plant (outside of the former syndicate), which is designed for an eventual output of five tons of aluminium per day. It is located near Conway, in North Wales, the name of the company being the Aluminium Corporation, Ltd. Direct current for the electrolytic cells is derived partly from a 4000-kw high-fall hydroelectric plant and partly from motor-generators supplied from a 20,000-volt, three-phase transmission line of a power company. The electrolytic furnaces are arranged in groups of 25 connected in series, and taking a working current of about 7500 amperes. When working at full power, each water-driven machine will run one group of 25 furnaces with a pressure of 120 to 130 volts. The behavior of each electrolytic furnace is studied by means of a conspicuous low-reading voltmeter, with which each is provided, and which indicates the voltage drop across the terminals of the furnace. The same company has a similar plant at Newcastle which has been in operation for some time. The Aluminium Corporation will also soon have their own bauxite plant, their bauxite mines being located in Southern France.

Miscellaneous.

Aluminium-Copper Alloys.—The alloys of aluminium and copper have formed the basis of a very exhaustive study of Messrs. Carpenter and Edwards. Their report was comprised in the Eighth Report to the Committee on Alloys of the Institute of Mechanical Engineers and was also translated into French and published in the July *Revue de Metallurgie*. The physical properties of all alloys carrying from 1 to 13 per cent aluminium are given in tabular and diagrammatic form. The most notable alloy is the one carrying 9.9 per cent aluminium, which has almost exactly the same properties as 0.35 per cent carbon steel.

Calcium Cyanamide.—One method of fixation of atmospheric nitrogen uses the reaction between calcium carbide and nitrogen (obtained from air) to produce calcium cyanamide at an elevated temperature. The decomposition of calcium carbide by nitrogen will not take place at temperatures as high as 1200° with pure carbide. With commercial carbide it takes place at 1100°. The presence of calcium chloride or fluoride acts as a catalyzing agent and causes the reaction to proceed at a much lower temperature. Dr. Gine Pollacci in *Zeitschrift für Elektrochemie* of September recommends potassium carbonate as a catalyzing agent for assisting this reaction. At a temperature as low as 900°, with an addition of 4 per cent of potassium carbonate, he obtained 23 per cent combined nitrogen. The nitrogen pressure in the furnace was 2 atmospheres.

Colloids.—Colloidal solutions are coagulated by the introduction of a metallic couple. Thus, W. Biltz notes in *Zeitschrift für Elektrochemie*, Sept. 4, that in a solution of gold when a zinc-copper couple is introduced no action takes place without the completion of electrical connection between the plates. On closing the circuit all the gold was precipitated as a purple deposit appearing to be an absorption product of gold and zinc hydroxide. The minute quantity of electrolyte present is sufficient to account for the action.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From our Special Correspondent.)

The Iron and Steel Institute Meetings.

The meetings of the Iron and Steel Institute, under the presidency of Sir Hugh Bell, were formally commenced on Monday, September 28, at Middlesborough, Yorkshire. [On account of limitations of space abstracts of the papers presented at the meeting had to be held over for our next issue.—Ed.]

The first two papers, namely, "Notes on a Workshop Microscope," by Mr. J. E. Stead, and Mr. W. Hawdon's paper on the "Iron and Steel Industries of the Cleveland District" evoked no discussion. Mr. T. C. Hutchinson's paper on "The Mechanical Cleaning of Iron Ores" was the subject of some remarks.

Mr. H. Pilkington thought the assertion that the picking belt would be applicable to any iron ore did not apply to the Northamptonshire, Nottinghamshire and Leicestershire ores. These districts were growing in importance. Stone there was oxidized, and did not require calcination; some of the ores there were exceedingly lean, and the smelter only got 23 per cent of iron.

Mr. A. Windsor Richards put the matter briefly as the question "at what point was it remunerative to start picking out lean stone?"

Mr. Hutchinson, in his reply, pointed out that Mr. Pilkington referred to Midland ores in which the impurities were mainly lime, whereas in the Cleveland ores dealt with at Skinningrove the impurities were silica. The cost per ton of ironstone discharged into the furnace was just over two cents. This covered interest on capital, redemption and repairs. As to the particular point at which it paid to throw out stone, that everyone must judge for himself. Personally he would throw out all stone and pay for a portion of it with under 27 per cent of iron.

On Wednesday, the 30th, Mr. E. H. Saniter read his paper on a "Test for Ascertaining the Relative Wearing Properties of Rail Steel." In the subsequent discussion Mr. Gledhill said the point in the paper which appealed to him was the superior wearing qualities arising from the percentage of nickel. The use of nickel was, however, so expensive as practically to preclude its employment for rail manufacture. He suggested in place of nickel the use of $1\frac{1}{2}$ to 2 per cent of chrome, which could be obtained at one-seventh the cost of nickel. A high-carbon chrome steel would seem to him to be possessed of good wearing qualities.

Mr. E. H. Saniter in his reply said he had made such a chrome rail and found that it broke into two or three pieces under the drop test.

Mr. Charles H. Merz's paper, on "Power Supply and Its Effect on the Industries of the Northeast Coast," which followed, produced a good discussion. Mr. T. Westgarth, in acknowledging the value of the paper, paid special attention to the use of gas engines. He advocated the use of waste gas from furnaces directly in a moderately large gas engine, and instanced gas-engine developments at Messrs. Hickmans, at Barrow, at Coltness and at Skinningrove. Although a 5000-hp gas engine was at work at San Francisco, most makers were not prepared to go beyond 3000 hp.

Mr. A. Gouvy said that it might be claimed that a well-designed gas engine could be built for continuous running without calling for more maintenance than a steam engine. The gas used should, of course, be cleaned down to 0.3 gram per cubic centimeter.

Mr. D. Selby-Biggs said that to his list of determining factors Mr. Merz might have added exhaust steam. He had recently been making an investigation in Westphalia and Silesia as to how works were producing their electricity and at what rates. It could be taken that where there was available a waste asset in the form of exhaust steam or blast furnace gas and the power requirements of the works were sufficiently large,

it ought to be possible to produce power at the rate of 0.5 cent per kw-hour. From coal it was possible to produce the power at 0.7 to 0.8 cent per unit if large outputs were being considered. In Westphalia, at one place he visited, they were producing between 14,000 and 15,000 horse-power in gas-engine stations, principally for supply to collieries. Mr. Adolph Greiner outlined the system employed at the Cockerill works, where the electricity department sold at 1 cent per kw-hour to the other departments.

Mr. W. Hawdon said that, at Sir B. Samuelson & Co.'s, they had put in as generating plant, low-pressure turbines driven by the exhaust steam of blowing engines. They also generated power by surplus high-pressure steam in a high-pressure turbine, which was a new channel of profit for blast furnace proprietors not connected with steel works.

The second paper on Wednesday, Messrs. C. Koettgen and C. A. Ablett's "Some Results of Experience with Electrically-Driven Rolling Mills," was also, strictly speaking, more mechanical than metallurgical. In the discussion, Mr. A. Lamberter referred to an electrically-driven reversing mill at Messrs. Dorman, Long & Co.'s, and also outlined a method of using a constantly running motor possessing many advantages of the Ilgner system without being so costly to install.

Messrs. W. J. Larke, H. Crowe and A. Greiner spoke on technical points connected with the mechanism.

There was no discussion on Mr. Sherard O. Cowper-Coles' paper "On the Production of Finished Iron Sheets and Tubes in One Operation," which followed (published in our November issue), or on Mr. A. E. Pratt's paper entitled "The Future Development of the Metal Mixer." This was owing to lack of time.

On Thursday, Oct. 1, a paper by Prof. W. A. Bone and Mr. R. V. Wheeler on "Further Experiments Upon Gas-Producer Practice" was read, and one by Prof. Armstrong on "The Scientific Control of Fuel Consumption." Being similar in subject, both papers were discussed together. Mr. A. Sahlin, on this subject, said that his firm had, by experience, established the rate of gasification in producers with undisturbed fuel bed at from 10 lb. to 18 lb. per hour per square foot of fire surface, irrespective of type. By agitating the fire zone they found by experiment that as high as 32 lb. per square foot could be reached. Mr. Lindsay Forster referred to some experiments with blast at temperatures of 52°, 55° and 60° C., in which satisfactory results had been obtained at the lowest temperature. Prof. Bone instanced a German works where the blast was used as low as 45°, but they were only gasifying from 10 cwt. to 12 cwt. per hour, and were working with cold blast.

Mr. R. V. Wheeler then read a paper on "The Chemical Control of the Basic Open-Hearth Process," written in conjunction with Mr. A. Harrison. In the discussion, Mr. Adolph Greiner said it was of great importance that the steel maker should know what was going on in the bath and that different phases of the melt should be carefully followed. He believed in analyses—if analyses could be made quickly—and at Seraing they had the means of making analyses accurately, simply and quickly. The determination of carbon took about 10 minutes, sulphur a little more, and manganese 9 to 10 minutes, while by the new method they could arrive at the phosphorus in less than 10 minutes.

The authors said that the elimination of sulphur could not be relied upon, but they were using the Saniter process with fluor-spar to obtain their results. They credit the Talbot process with a desulphurizing effect, which was not claimed by the inventor. The very low loss of manganese was probably due to oxidation, but if not due to oxidation it did not correspond with the elimination of sulphur shown in the steel. Analytical methods had been used in the Middlesborough district for the last 13 years, and the methods suggested by the author were not the best which could be employed. He certainly objected to burning color carbons in a gas flame with the expectation of getting a good result.

The remaining papers for this day were Prof. Carpenter's on "The Freezing Point of Iron"; Prof. E. D. Campbell's on "The Constitution of Carbon Steels," and Mr. A. Jouve's, "On the Influence of Silicon on the Physical and Chemical Properties of Iron." These, unfortunately, were not discussed, probably owing to the limited time available.

Sulphur in Iron Ore.

At the meeting of the Staffordshire Iron and Steel Institute, on Oct. 17, Mr. Stead gave the results of a number of experiments recently made in his laboratory to determine the relative harmfulness of different sulphur-bearing minerals in iron ores. The experiments were made with iron ores mixed with iron pyrites, sulphate of lime and sulphate of baryta, respectively, and then smelted in crucibles. The several mixtures were smelted in large plumbago crucibles divided into sections, so that comparative smeltings could be done at the same time and under the same conditions. The various mixtures were placed in pockets in the crucibles, which were then heated for an hour to about 900° C., and finally for half an hour to near whiteness. The lining of the crucibles was, in the first trial, coke dust, and in subsequent trials, charcoal powder mixed with starch paste. Mr. Stead summarized his results as follows: "In reviewing the work and averaging the results it will be seen that the average of No. 1 BO 4 series indicates that 1 per cent of sulphur in the ore in the state of Fe_2S — CaSO_4 and BaSO_4 leaves sulphur in the pig in the following proportions: Pyrites, 100 sulphur; calcium sulphate, 94 sulphur; barium sulphate, 61 sulphur. These results must not be taken as absolutely indisputable, but approximate only. They show how readily sulphur in any combination is liable to be retained by the iron in the blast furnace. It seemed reasonable to believe that the bases, calcium and barium, associated with the sulphur in calcium sulphate and barium sulphate must check the sulphur from passing into the iron, but, as a matter of fact, their influence in that direction is very feeble. To place the question absolutely at rest, the comparative smelting should be done in gas-fired furnaces and the temperature be controlled by pyrometer."

Smoke.

In his paper before the Association of Engineers-in-Charge Mr. J. Swinburne made some very pertinent remarks on the subject of "Smoke." He distinctly accuses the furnace, as in ordinary use, of imperfect combustion. It does not appear at first sight, says the author, easy to raise smoke to a high temperature, but it was not impossible. The gases from hand-fed fires were generally led straight to iron surfaces cooled by the water of the boiler, so that the tar had no chance of getting burned. If the fire were itself in a fire-brick chamber, and the gases had to pass over a reasonable amount of white-hot fire-brick before any attempt was made to abstract the heat, it is quite possible there would be no smoke even with hand stoking. He believed the general principle in furnaces of abstracting heat from the fire and gases at the earliest possible moment was entirely wrong. He suggested that the proper way was to leave the gases as long as possible before beginning to cool them, and not to heat the boiler shell or tubes by direct action of the fire or even by radiation from it. No heat should be taken from the fire or from the gases until all the smoke was completely burnt. The boilermaker seemed to have a fixed idea that the fire ought to be inside the boiler, and the water ought to be as close to the fire as possible. In reality, the fuel was too close to its work. The idea that the best way to heat anything was to put it right into a flame was very widespread. The Bunsen burner, the table and laboratory spirit lamp, and gas stoves were familiar examples. The gas engineer has at last found out this simple thing, that the burner must not play on the saucepan. The products of incomplete combustion coming into a room as the result of burners playing on lumps of clay or asbestos were far worse than the products from the same amount of gas burned by Bunsen or bat's-wing burners. In boilers there is no reason why the furnace should not be out-

side in the form of a fire-brick structure in which is allowed ample room for the hydro-carbons and air to mix thoroughly and time for the combustion to be complete.

Blast Furnace.

A new type of blast furnace has recently been erected at the Brymbo Steel Co.'s works, near Wrexham, by the Pearson & Knowles Coal & Iron Co., Ltd., of Warrington. This new furnace is 70 ft. high and has a hearth diameter of 11 ft., the height of which above ground level is 8 ft. 6 in., so that hot metal may be run direct into ladles for transference to the steel works mixer. The furnace top is closed by a bell and hopper, the former being arranged with a 5-ft. central tube forming the gas out-take for the furnace. The connection between the moving bell and the fixed vertical gas off tube is maintained gas-tight by a water seal. With this arrangement the stock line of the furnace is nearer the level of the charging platform than is the case with furnaces having the usual side down comers, consequently there is less breakage of coke during the charging of the furnace. Further, there is the additional advantage secured by causing the gas leaving the furnace to pass finally off from the center. The Brymbo Steel Co., Ltd., have a large installation of gas engines for power purposes, which are worked from their blast furnaces, and as it is found to be advantageous to their regular working to prevent fluctuations in the gas pressure when the furnace bell is lowered, the furnace hopper is entirely closed by means of a hood during this period. The bell and hood are worked by separate steam cylinders at the top of the furnace. The furnace is provided with a steel bosh jacket arranged to be cooled by three sets of water-spray pipes and petticoat drip rings. The cooling water is drained away by a circular trough at the bottom of the jacket. There are eight forged copper tuyeres fitting into water-cooled circular blocks made of cast copper, which in turn are carried in a cast-steel tuyere belt encircling the hearth of the furnace. Access to the tuyeres is given by a platform carried up on the furnace columns. The water supply to the tuyeres is worked on an equilibrium system which is a combination of the usual pressure system and the Foster vacuum system, and so arranged that there is an ample flow of water to the tuyere nose, notwithstanding the fact that the pressure at that point never rises over 2 lb. above atmospheric pressure. In the furnace casing above the lintel there are fitted 144 cast-iron cooling blocks arranged in eight rows, access to which is obtained by two circular platforms reached by a stairway from the ground. Cast-iron blocks are inserted in the brickwork near the stock line so as to protect the bricks from the falling stock. The gas passes from the tube above the furnace bell into a dust-catcher having a coned top and bottom.

Platinum.

The *Chemical Trade Journal*, quoting from a report of Lieut. I. A. Lossiev to the Russian Minister of the Interior, gives some interesting information on the position of the platinum market. It is expected that the decline in price will continue for some time yet, until all the small and medium platinum concerns in the Urals have been completely ruined. Even now at 4 rubles per pood, many places in the northern Urals are being worked at a loss. The continuous decline in the value of platinum is due to the maneuvers of several groups or syndicates of foreign capitalists, who are exerting every effort to get control of the Urals platinum industry (practically the only one in the world) in order to control the production and the market as well. The plan of the syndicates has apparently been to buy up all the government platinum areas available, and to buy in advance the production of all the large platinum houses. It is suggested that the government should intervene, prohibiting the exportation of crude platinum and allowing only refined metal to be exported.

Electric Units.

The International Conference on Electrical Units and

Standards held its first meeting on Monday, Oct. 12, when attention was principally directed to the definition of the ohm. Lord Raleigh expressed the opinion that it might be better not to adopt a mercury standard at all, because absolute methods of measurement would probably very soon give us all that was necessary. Mr. Trittee also, from another point of view, was by no means in favor of mercury standards, for the reason that such standards have not met with any great success among the general body of workers in this country. There was also a question whether the length and weight of the mercury column should be fixed once for all. Dr. Warburg was of the opinion that this should be so, as it was extremely inconvenient for commercial purposes to have different values from time to time. The suggestion was made by Dr. Rosa that the length of the mercury standard should be fixed once for all as 1 m, the weight being correspondingly reduced.

This was, in the form of a resolution, ultimately rejected by the technical committee.

The second meeting of the conference took place on Wednesday, Oct. 14. The question under consideration was Resolution V, that the ampere is the second primary unit. After some discussion, and a proposal in favor of the volt as the second primary unit, the meeting decided in favor of the ampere, defined by the electrochemical equivalent of silver. The exact figure to be adopted was referred to the technical committee.

The proceedings of the technical committee on Wednesday, Oct. 14, effected no change in the figure for the electrochemical equivalent.

On Thursday, Oct. 15, the committee suggested various emendations in the directions for ascertaining the mercury ohm, and referred the final drafting of the specification to a sub-committee.

The committee then considered further the value of the electrochemical equivalent of silver, and adopted finally the figure 0.001182.

On Friday, Oct. 16, the conference, on the motion of Dr. Glazebrook, decided to adopt the recommendation of the technical committee "That the conference do not alter the length of the mercury column in the definition of the international ohm from 106.300 cm to 1 m."

The ampere was then further discussed, and the final figure for the electrochemical equivalent accepted as 0.0011800.

The conference then recommended the adoption of the international ohm, ampere and volt, as defined by them, for the purpose of electrical measurements, and as a basis for legislation, and recommended the establishment of a permanent commission to secure uniformity of administration in relation to electrical units and standards in the future.

Exhibition.—At the Franco-British Exhibition the following awards have been made in the department of electrochemistry; Diploma for grand prize, Sherard Cowper-Coles & Co., Ltd.; diploma for gold medal, Berry, Skinner & Co.; Ozonair, Ltd.; Dr. Henry F. S. Sand.

Market Prices.—Tin has had a downward tendency for the latter part of October, reviving somewhat on the 19th. The price started at £134 and is now (Oct. 27) in the neighborhood of £133.

Copper has been fairly steady, and is at present, if anything, inclined to harden. Commenced, £59 15 0; present price, £61.

English Lead has been steady in the neighborhood of £14.

Hematite has fallen pretty generally throughout the month. On the first £3 0 6 was quoted, which had fallen by the 18th to £2 19 0, and by the 23d to £2 18 9.

Cleveland Warrants have dropped from £2 10 0 to £2 8 6. A pretty steady decline.

Scotch Pig also down from £2 16 0 to £2 14 0.

Chemicals:

Sulphate of ammonia, f. o. b. Liverpool, per ton.....	£11	10	0
Copper sulphate, per ton.....	19	5	0
Caustic soda, white, 77 per cent, per ton.....	11	2	6
Bleaching powder, 35 per cent, per ton.....	4	5	0
Antimony, black sulphide powder, per ton.....	25	0	0
Shellac, Standard T., Orange Spots, per cwt.....	4	15	0

Carbolic acid, liquid, 97 to 99 per cent, per gal.....	1	0
Cresosote, good ordinary liquid, per gal.....	2	½
Naphtha solvent, 90 per cent at 150 deg. C., f.o.b, per gal.	10	½

RECENT METALLURGICAL PATENTS.

Iron and Steel.

Dry Blast.—Mr. Gayley's dry blast system has the great advantage of increasing the output of a blast furnace to a very considerable extent and at the same time makes its operation independent of the weather. A new method for removing the moisture from the air used for the blast is patented by Mr. Louis Block, formerly connected with the De la Vergne Machine Co. (903,353, Nov. 10, 1908). He compresses the air to a tension greater than the "furnace tension" (i. e., the pressure, say, 20 lb. above atmosphere, at which the air blown into the blast furnace through the ordinary tuyers after being heated in the stoves is able to overcome the resistance and rise upward through the charge of the blast furnace). The heat of compression is disposed of by cooling the compressed air by water, or, still better, by cold air after it has deposited its moisture. After this treatment has cooled the compressed air and condensed any surplus moisture, the air is allowed to again expand and thereby to drive an engine which aids in the compression of the air. The arrangement in its simplest form is shown in Fig. 1. *A* is an air compressor. *A*¹ is a pipe of

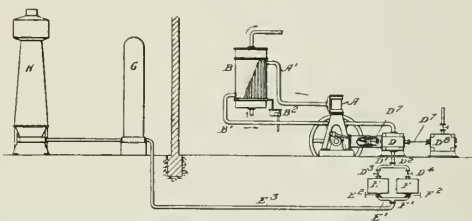


FIG. 1.—DRY-BLAST SYSTEM.

sufficient capacity conducting the air at high tension, say, 60 lb. per square inch, and at a high temperature due to the compression to the moderate cooler or condenser *B*, which is a strong casing provided with tubes. Ordinary river water or well water, if such can be commanded, is passed through the spaces between, while the hot compressed air flows through the tubes. The purpose being to expose this air to metal of sufficient area kept at near the temperature of the cooling medium, say, 35° to 90° Fahr. *B*¹ is a pipe carrying away the air still under its high tension and cool, but not cold. It is shown as leading directly to the cylinder *D* of a motor-engine, analogous to a steam engine. It may be an ordinary steam engine with suitable provisions for thawing if a valve becomes clogged by ice. In this cylinder it is caused by suitably actuated valves to act alternately on the opposite side of a piston, not shown, and through a piston rod *D*¹, to aid in driving the compressor *A* or to do other useful work. The admission-valve or valves should be worked in the same manner as the corresponding parts in a good steam engine so as to cut off the supply of air when only a third or some other fraction of the stroke has been performed and thus to obtain power from the expansion as well as from the admission of the air, and utilize as far as may be all the power derivable from the expansion of the air from near the high tension, say, 60 lb. per square inch by gage, at which it left the compressor *A* too near the blast-furnace tension (say, 20 lb.). *D*² and *D*³ are divergent pipes controlled by valves *D*⁴ and *D*⁵, arranged to conduct the expanded air to snow boxes *E* and *F* of ordinary construction. The pressure is now down to that required to serve in the blast furnace. The soft ice or snow, if any is deposited, may be alternately re-

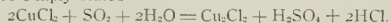
moved from the snow boxes, and the air pretty thoroughly rid of its moisture, may be conducted by any suitable passages or vessels, as the pipes E^1 , E^2 and F^1 controlled by the valves E^2 , F^2 , connecting to the stove G , and after being there heated, flows through the twyers into the blast furnace H . A more elaborate form of apparatus, in which the compressing is effected in two stages, is also described.

Copper.

Leaching Process.—A modification of the Hunt and Douglas process is patented by Mr. Fred. Laist, of Butte, Mont. (903,732, Nov. 10, 1908). The process relates to leaching oxidized copper ores with a dilute solution of sulphuric acid which contains chlorine in the form of a chloride, such as sodium chloride, ferrous chloride or calcium chloride, in quantity sufficient to form the sub-chloride with the copper. Having dissolved the copper from the ore, it is to be precipitated from the resultant solution as the sub-chloride, or cuprous chloride (Cu_2Cl_2). This is done preferably by running the cold solution down an absorbent tower up which sulphur dioxide gases (generated by burning pyrites, sulphur, etc.) are passing. The sulphur dioxide is absorbed by the cold solution, so that a solution containing 2 per cent to 4 per cent of sulphur dioxide is obtained. The percentage of sulphur dioxide gas absorbed must be at least one-half of the percentage of copper which the solution contains. This solution is now run into a boiler, lined with an acid-proof metal, and containing steam coils for heating and a safety valve adjusted to go off at about 15 lbs. pressure. Here it is brought to boiling and the following reaction takes place:

$$2\text{CuSO}_4 + 2\text{NaCl} + \text{SO}_2 + 2\text{H}_2\text{O} = \text{Cu}_2\text{Cl}_2 + 2\text{H}_2\text{SO}_4 + \text{Na}_2\text{SO}_4$$

or more simply stated



The cuprous chloride being insoluble separates out, especially on cooling the solution, as a white crystalline powder which is collected and dried and which can readily be converted into metallic copper. The solution, which contains a large amount of regenerated acid, is used for leaching fresh quantities of ore. The essential differences from the Hunt-Douglas process consist in absorbing the sulphur dioxide in the cold copper solution and then heating under pressure to complete the reaction between the sulphur dioxide and the cupric chloride. The Hunt-Douglas method was to inject sulphur dioxide into the hot copper solution. This method is not nearly so economical of sulphur dioxide nor so convenient of manipulation as the present modification. Moreover, the sulphur dioxide obtained in practice always contains some oxygen. Hence an oxidation of the precipitated cuprous chloride always accompanies the reduction of the cupric chloride, which makes it impossible to obtain a complete conversion of the copper into cuprous chloride. In the new modification this does not take place, since the oxygen comes in contact only with the cold solution and before the formation of cuprous chloride has properly started. Heating under pressure very materially aids the reduction, because it keeps the sulphur dioxide in the solution until the reaction temperature (which is near 100°C) is reached. It is very difficult to obtain a precipitation of more than 75 per cent of the copper in the solution when heating in the open. Under pressure 90 per cent to 95 per cent can be brought down. In fact, the completeness of precipitation is limited only by the slight solubility of cuprous chloride.

Miscellaneous.

Melting and Refining Furnace.—S. T. Bleyer patents (903,163, November 10, 1908) a modification of the well-known Schwartz furnace of the Hawley Down Draft Furnace Co. of Chicago. It is specially suitable for brass and steel. Sections of the whole of the furnace and of the melting chamber are shown in Fig. 2. It is a tilting furnace with a charging opening 9, and a pouring outlet 12. The burner comprises two nozzles 13, inserted through the upper part of the furnace body above the outlet 12 and connecting with an air supply pipe 14. An oil

supply pipe 15 communicates with two injectors 16 inserted in the nozzles or burners proper and adapted to supply the fuel which is vaporized and mixed with air and burned in the furnace chamber to make intense flame jets for melting any metal on the hearth. This hearth is flat in order that all the molten metal thereon shall be of uniform depth. The air blast mechanism comprises a series of twyers 17, arranged at opposite sides

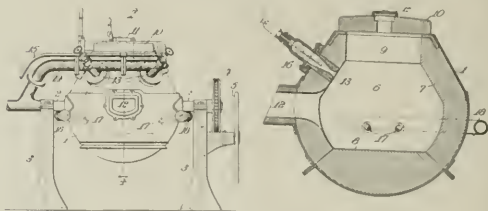


FIG. 2.—MELTING FURNACE.

of the furnace and having an angular disposition with respect to the burners of somewhat less than 90° . These twyers are located below the trunnions and above the line of metal when molten and are directed slightly downwardly, so that the air blasts discharged therefrom will strike the metal. Moreover, these twyers are arranged in two pairs at opposite sides of the furnace, the members of each pair converging, with the result that the air blasts focus substantially at the central axis of the furnace. The air is supplied to the twyers through an air supply pipe 18 curved around a little more than half of the furnace and connected to the twyers. The operation is as follows: The metal to be melted is placed upon the hearth and the burners 13 are started, whereby the metal is melted. If it is desired to also refine the charge, the burners are shut off and the twyers are opened, whereupon air blasts are directed against the body of the metal.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electrolytic Processes.

Metallic Tubes by Electrolysis.—Tubes, etc., have been made in the past by electrolytic deposition according to various methods, the essential feature of all of which is thorough circulation of the electrolyte, generally by rotation of the cathode. Fig. 1 shows an apparatus of Paul Borgnet, Liege, Belgium (903,164, Nov. 10, 1908). The two mandrels 4 on which the metal is to be deposited are revolved by means of the belts 5

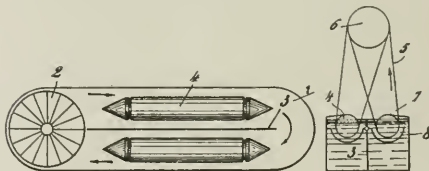


FIG. 1.—METALLIC TUBES BY ELECTROLYSIS.

driven by the pulley 6. The anodes 8 are arranged in proximity to the mandrels 4, which are the cathodes. Besides revolving the cathodes the electrolyte is further circulated by means of the wheel 2.

Electroplating; Alcohol Electrolyte; Plating on Aluminium.—Solutions of metallic salts in water are the rule in electroplating, although in special cases, where the desired deposit would react with water, it has been suggested to

employ other solvents than water. O. Meyer (902,755, Nov. 3, 1908) patents the use of a plating bath, consisting of a solution of a chloride of the metal to be deposited in alcohol. He states that the alcohol may be either commercial ethylalcohol or methylalcohol or denatured alcohol. The chief advantage desired is the practical suppression of the evolution of hydrogen gas on the surface to be plated. The electrolyte may be made by dissolving the metal chloride in the alcohol. Another way is to add one or several per cent of pure, concentrated hydrochloric acid to commercial alcohol and start electrolysis with an anode of the metal to be plated whereby the metal chloride

is produced by anodic reaction. It is stated that in this way, at ordinary temperature and without any further additions, an "excellent electrolyte" is formed for depositing gold, copper, nickel, cobalt, tin and is produced by anodic reaction. metallic form. From $2\frac{1}{2}$ to 3 volts are said to be required. The process is not applicable for plating with silver and lead, and is not recommended for plating with platinum and zinc. It is claimed that alloys (like brass) can be easily deposited by this method, either by dissolving a mixture of various metallic chlorides in alcohol or by employing anodes made of different metals. Zinc, nickel, copper and tin may form a variety of colors on the same cathode. Alloys of other metals with aluminium (though not pure aluminium) may also be deposited. The process is also stated to solve in an easy way the problem of plating

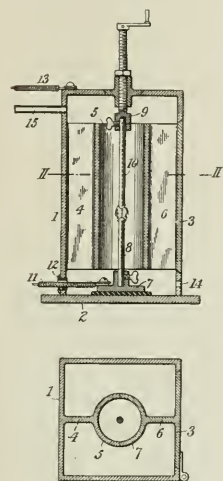


FIG. 2.—ARC APPARATUS FOR FIXATION OF ATMOSPHERIC NITROGEN.

other metals upon aluminium. The trouble has always been supposed to be due to the invisible film of aluminium oxide, which always exists on aluminium surfaces and which prevents other metals from sticking. If the aluminium surface to be plated is first made anode in the alcohol plating bath, the oxide film is reduced within a few minutes, and when then the connections are reversed and the aluminium surface is made cathode, the oxide film does not form again in the alcohol solution and "the electrodeposited metal strikes upon real, bare aluminium and adheres to it."

Electrotypes.—In the manufacture of electrotypes lead has to a considerable extent supplanted wax as a matrix material. To facilitate the separation of the electrotype from the lead matrix, the latter is usually covered with a film of graphite, and this is satisfactory in many cases, although difficulties are experienced when the matrix has deep cavities. C. Revrdys (903,404, Nov. 10, 1908, assigned to F. Wesel Manufacturing Company of Brooklyn) treats the lead matrix with carbonic acid to produce a thin film of carbonate of lead. This film has no bad effect on the deposition of the electrotype, while it renders its subsequent operation from the matrix very convenient. It is recommended to employ the carbonic acid gas under heat in order to quicken the reaction, and for this purpose the inventor employs a jet of gas on the surface of the matrix by an air blast or by the use of steam. An oily or fatty substance, such as paraffine, oil or an alcoholic solution of rosin, may be added. The blast of the gas entrains the oily substance so that it is spread upon the surface together with the gas.

Discharges Through Gases.

Fixation of Atmospheric Nitrogen.—In the evolution of

processes for the fixation of atmospheric nitrogen the tendency has been marked to use arcs rather than sparks and the endeavor has been to get as large an arc surface as possible (for instance, by spreading the arc out by means of an alternating magnetic field in the Birkeland-Ede process). It was therefore to be expected that the progress made in the last years by illuminating engineers with the so-called "flaming arc" would be made use of by electrochemists. Flaming arcs are produced between chemically impregnated electrodes and one of the characteristic features of the flaming arc is that light is given off not only from the incandescent terminals of the electrodes, but from the vapor zone between the electrodes and that the electrodes can be drawn further apart than is possible with ordinary carbon electrodes. I. L. Roberts (902,607, Nov. 3, 1908) recommends for these reasons the flaming arc for the fixation of atmospheric nitrogen and patents specifically the use of chromium-iron electrodes. They are made by casting an alloy of iron and chromium, containing "as large a proportion as possible" of chromium. The apparatus is shown in Fig. 2, where 8 and 10 are the electrodes. The air enters at 14 and leaves through 15. The fixation of the nitrogen occurs in the inner cylinder. The surrounding ring-shaped space of air serves as heat-insulator. The inner cylinder is constructed in halves 5 and 7. The half 5 is connected by the thin web 4 with wall 1, while the half 7 is connected by web 6 with the removable door 3 in the opposite wall. It is, therefore, easy to take the apparatus apart for inspection and renewal of electrodes.

Ozone.—At the recent Navy Exhibition in Berlin two systems of ozone ventilators were shown. The Siemens & Halske Co. arranges the ozonizer tubes on the inner side of rectangular vessel, and the ventilator throws the ozonized air into the outer spaces. The Allgemeine Elektrizitäts Gesellschaft makes use of the fact that the incandescent Nernst filament ozonizes the surrounding air. In their apparatus the air is driven along the filament by a small ventilator. (Elektrotech. Zeitschr., Oct. 29.)

Storage Batteries.

Formation.—Storage battery plates have been formed before by anodic treatment in a mixed solution of sulphuric acid and nitric acid. The disadvantage is that the nitric acid is converted during electrolysis into nitrous acid. To prevent this, W. Morrison (903,752, Nov. 10, 1908) adds to the mixed solution a soluble salt of manganese, such as a permanganate of potassium. Its effect is to convert the nitrous acid back into nitric acid and also sulphurous acid back to sulphuric acid.

Automobile Battery.—Mechanical details of construction of a battery for use in automobiles are patented by John L. Smith and Malcom O. Smith (903,799, Nov. 10, 1908). The first claim refers to "a storage battery cell comprising two lead plates, two elastic non-conducting frames in which the edges of the plates are seated, and a mud guard frame of non-elastic non-conducting material clamped between the plate-holding frames, each frame being composed of two side bars and a bottom bar, the vertical dimension of the bottom bar of said mud guard frame being greater than that of the corresponding bars of the plate holding frames between which it is clamped."

Electric Furnaces.

Alloy for Resistors.—An alloy suitable for electric heating and rheostat work and for resistors for electric furnaces, on account of its high electric resistivity and its ability to withstand a red heat for long continued service, is patented by John T. H. Dempster (901,428, Oct. 20, 1908; assigned to General Electric Co.). It consists essentially of 62 parts by weight of nickel, 20 iron, 13 chromium, and 5 manganese. The alloy can be rolled and drawn into extremely fine wire or ribbon, having a resistivity of 117 microhms per cubic centimeter (70 times that of pure copper). The alloy is prepared in an oil furnace and then worked in the ordinary way by rolling

and drawing. Other valuable properties of the alloy are that it resists the action of moisture and is very acid proof; it is insoluble even in concentrated mineral acids; boiling strong aqua regia being required for its solution. The alloy withstands a red heat for a long continued service, and although under such conditions it oxidizes slowly, the oxide is coherent and does not materially change the conductivity.

Regulation of Polyphase Furnaces.—In operating an electric furnace with polyphase currents, it is important to see that the different phases carry equal loads, so as not to unbalance the supply system. If, for instance, a three-phase furnace is operated with three arcs, each playing between the end of three symmetrically arranged electrodes and the charge, then the charge represents the neutral point of the three-phase system. An additional neutral electrode may be placed in contact with the charge and connected with the neutral point of the supply system either directly or through the earth. If now three voltmeters are inserted between each of the three real electrodes and the neutral electrodes, then the readings of the three voltmeters will be equal, if the system is balanced. If the reading of one of the voltmeters differs from those of the other two, it indicates that the electrode connected to the former carries either too much or not enough current. By adjusting the position of the electrode, the system may again be balanced. Of course, the indications of the three voltmeters may be made to act on an automatic regulating system which adjusts the position of the electrodes to keep the system balanced. In this arrangement the additional neutral fourth electrode is evidently an undesirable complication. Richard Fleming (904,194, Nov. 17, 1908; assigned to General Electric Co.) avoids it by establishing an artificial neutral outside of the furnace, which is "a counterpart or image of the interior neutral point." The outer end of each of the three electrodes is connected with an inductance coil, and the three free ends of the three inductance coils are connected together, the connection forming the artificial neutral point. The three voltmeters are now connected in parallel with the three inductance coils. Otherwise the arrangement is exactly the same as described above.

Phosphoric Acid from Phosphate Rock.—Fred. J. Maywald (902,157, Oct. 27, 1908) produces phosphoric acid from aluminium phosphate, calcium phosphate, and mixtures of calcium, aluminium, and iron phosphates, all of which are relatively infusible. The finely pulverized phosphate rock, mixed with a trace of powdered carbon, is placed in a crucible, provided with two carbon electrodes, and heated to a high temperature, but below the melting point of the mass. Either a short arc is used (the voltage being from 40 to 60 at the beginning) or resistance heating is employed, the comminuted mass between the two electrodes acting itself as the resistor. When not heated to the melting point, but above the dissociation temperature of the phosphate, the mass remains in a porous condition, the phosphate dissociates and the P_2O_5 distills away leaving a residue of base or basic phosphates. The P_2O_5 is collected in a special condensing chamber. A slight amount of air is admitted to oxidize any phosphorus that may be formed; this air may be introduced through a slight space left between crucible and condensing hood. The P_2O_5 is condensed in form of a powder, which is readily soluble in cold water.

Zinc from Pyrites.—The problem of winning zinc from pyrite residues has attracted the attention of a German professor of physiology, Karl Kaiser (904,263, Nov. 17, 1908). He employs an electric furnace of pear-shape, the electrodes being introduced from the sides. The bottom of the furnace is perforated, these perforations being connected to a gas supply pipe to permit the admission of an oxidizing or a reducing gas into the furnace. The pyrite residue is introduced into the furnaces together with fluxes and the mass is heated. "As soon as the necessary temperature has been attained, i. e., in most cases the melting temperature of the mixture, an oxidizing gas

such as atmospheric air is introduced into the heated mass, this oxidizing gas serving to oxidize all combustible impurities in the ore, the gaseous products resulting therefrom being led off from the furnace. When this stage of the process is complete, a reducing gas is introduced to the heated mass. For this purpose, gaseous carbon compounds and hydrogen can be employed. The most suitable for the process are carbon monoxide, water gas, and Dowson gas. The volatile metals escaping in gaseous form, for example, the zinc, are led out of the furnace and collected in a suitable receiver, where they are condensed in a known manner, and thus separated from any gases which pass out of them. The liquid constituents, for example, the iron, are led off from the lower part of the furnace and cast directly into ingots or bars. . . . By the mere roasting and reducing of materials such as contain zinc and iron with sulphur, it is impossible or only possible with great difficulty to separate the different metals completely from each other, for instance the zinc from the iron, the metals being in a fixed combination as in the state of an alloy."

The American Smelting & Refining Co.

Recent attacks, during the political campaign in Colorado, on the American Smelting & Refining Co. have produced an official reply by Mr. Franklin Guiterman, general manager of the Colorado district, from which we quote the following:

As to the price of lead, Mr. Guiterman says: "The American Smelting & Refining Co., large as it is, is and has been utterly without influence on the quotation applying to silver, copper and zinc. It has, as the greatest producer of lead in the United States, lent its sustaining influence to the maintenance of lead prices and to the extent which the company has been able to aid in the creation of better prices for lead, the lead producers of the United States have shared the benefit.

"The policy of the company with respect to the mining operators in Colorado has been one of consistent reduction in ore treatment charges as fast as improvements were introduced, which in the lowering of operating costs permitted such reductions to be made. In the policy which has actuated the company the salient principle has always been borne in mind to lend aid to such portion of the ore production which absolutely demanded it and to apply treatment charges on such other portions of the ore production which so far from hampering the output would, on the contrary, stimulate it to its utmost."

Mr. Guiterman points out the peculiar business of smelting of precious metal ores. "The industry is one which calls continually for a chemical adjustment of the ore charge and involves at the same time commercial considerations of greatest moment."

It is then emphasized that "it has been and always will be necessary to make such charges as will permit the greatest production of ores from all districts in order that the mining business may be stimulated to its highest degree and the maximum output obtained." For economy's sake works must be operated at nearly full capacity, and "the basis of calculation has been the operation of all the works of the company under full capacity."

"The American Smelting & Refining Co. has no monopoly in its business. It has no secret process nor has it a monopoly of the technical and business talent which is necessary to successfully conduct its enterprises. It has no privileges in the matter of secret railway rates, and has constantly exerted its efforts with the railways for the obtaining of minimum freight charges, the benefit of which, when secured, has been given to the ore producer.

"The company has been charged with the new crime of employing brains in the conduct of its business. It pleads guilty to this accusation, but in doing so claims that it should and does have a keen recognition of the fact that being entirely dependent on the prosperity of the mining industry, it certainly cannot thrive in its downfall."

Dry-Blast Plant of the Illinois Steel Company's South Works.

The principle of the Gayley process is to cool far below its dew point the air required for the blast in blast furnaces and for the Bessemer process, and thus to deprive the air of the greater portion of its moisture. Its humidity is thereby rendered normal under any climatic or atmospheric conditions. The steam thus eliminated by condensation collects on the surface of closely packed groups of piping along which the air is sweeping, and which are kept at low temperature by circulating through them a refrigerated solution of chloride of calcium.

The arrangement of the cooling compartments or chambers, and the manner in which the pipe groups are mounted therein, are described in the following article, which treats of an installation recently completed at the South Works of the Illinois Steel Co., South Chicago, Ill. This plant is especially interesting, as the Gayley process is here employed, not only in connection with blast furnaces, but also in connection with Bessemer plant. This is the first application to a Bessemer plant, and has proved very successful.

The refrigeration of the circulating fluid is accomplished by machinery and apparatus furnished and erected by The

Twenty-five stands of such double pipe condensers, grouped 12 pipes high, are provided for each machine, making in all 100 stands. While the division into four separate units is strictly maintained throughout for obvious reasons, yet connections and valves are arranged in such a manner as to permit



FIG. 2.—100 STANDS DOUBLE-PIPE AMMONIA CONDENSERS.

the operation of either two machines or all of them in combination on all or part of the ammonia condenser system.

The liquefied gas is collected in four receivers located near the oil traps and carried through individual pipes to the cooling apparatus, in which the liquid ammonia is evaporated by means of the heat transmitted to it from the circulating fluid employed for the refrigeration of the vast volume of air supply.

The cooling apparatus (Fig. 3) is installed in a building 68 ft. 4 in. long, 58 ft. 8 in. wide and 25 ft. in height, which adjoins the engine room. The floor, walls and ceiling of this room are well insulated with a double lining of cork board, 2 in. thick. The coolers are of the double pipe type, and set in four batteries of 20 stands each. Each stand consists of

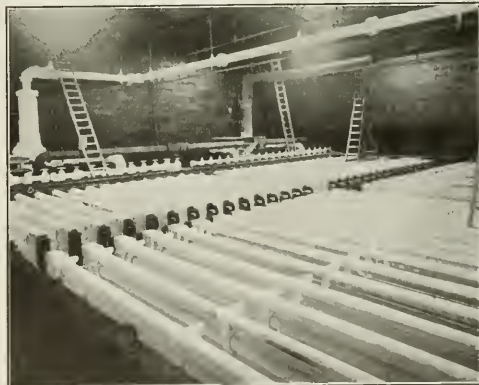


FIG. 3.—80 STANDS DOUBLE-PIPE BRINE COOLERS.

twelve 3-in. pipes, connected in circuit, and 2-in. pipes passing through them. A saturated solution of chloride of calcium, used as a circulating medium, is forced through the inner pipes and transmits its heat to the liquid ammonia contained in the annular spaces formed by the outer 3-in. pipes. By abstracting the heat from the circulating fluid, the liquid am-

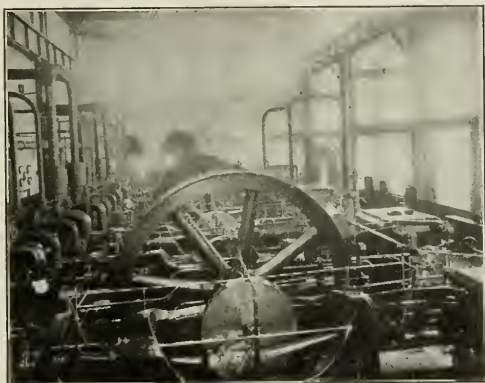


FIG. 1.—ENGINE ROOM IN SOUTH WORKS OF ILLINOIS STEEL CO. SHOWING FOUR 300-TON VILTER REFRIGERATING MACHINES.

Vilter Mfg. Co., 802 Clinton Street, Milwaukee, Wis. The entire plant is installed in structures especially provided for the purpose.

The main building, which is 102 ft. long and 53 ft. wide, accommodates on its first floor, which is 40 ft. in height, four refrigerating machines of 300 tons refrigerating capacity each (Fig. 1). They are of the duplex horizontal type, each machine consisting of a cross compound condensing Corliss engine and two ammonia compressors, placed opposite the high- and low-pressure steam cylinders, and connected to the crank disks on the ends of the common shaft. The size of the steam cylinders is 24 in. x 46 in., by 36-in. stroke, while the ammonia compressors are of 18-in. diameter and 36-in. stroke.

The Cooling Apparatus.—The ammonia compressors are provided with a set of two suction and two discharge valves, placed in each cylinder head and readily accessible. The gas discharged from the compressors passes through oil traps, of which one is provided for each machine and enters the condensers, which are placed on the second floor of the main building (Fig. 2). These condensers are of the double-pipe type, consisting of 2-in. pipes 18 ft. long, with 1¼-in. pipes passing through them for circulation of the cooling of condensing water.

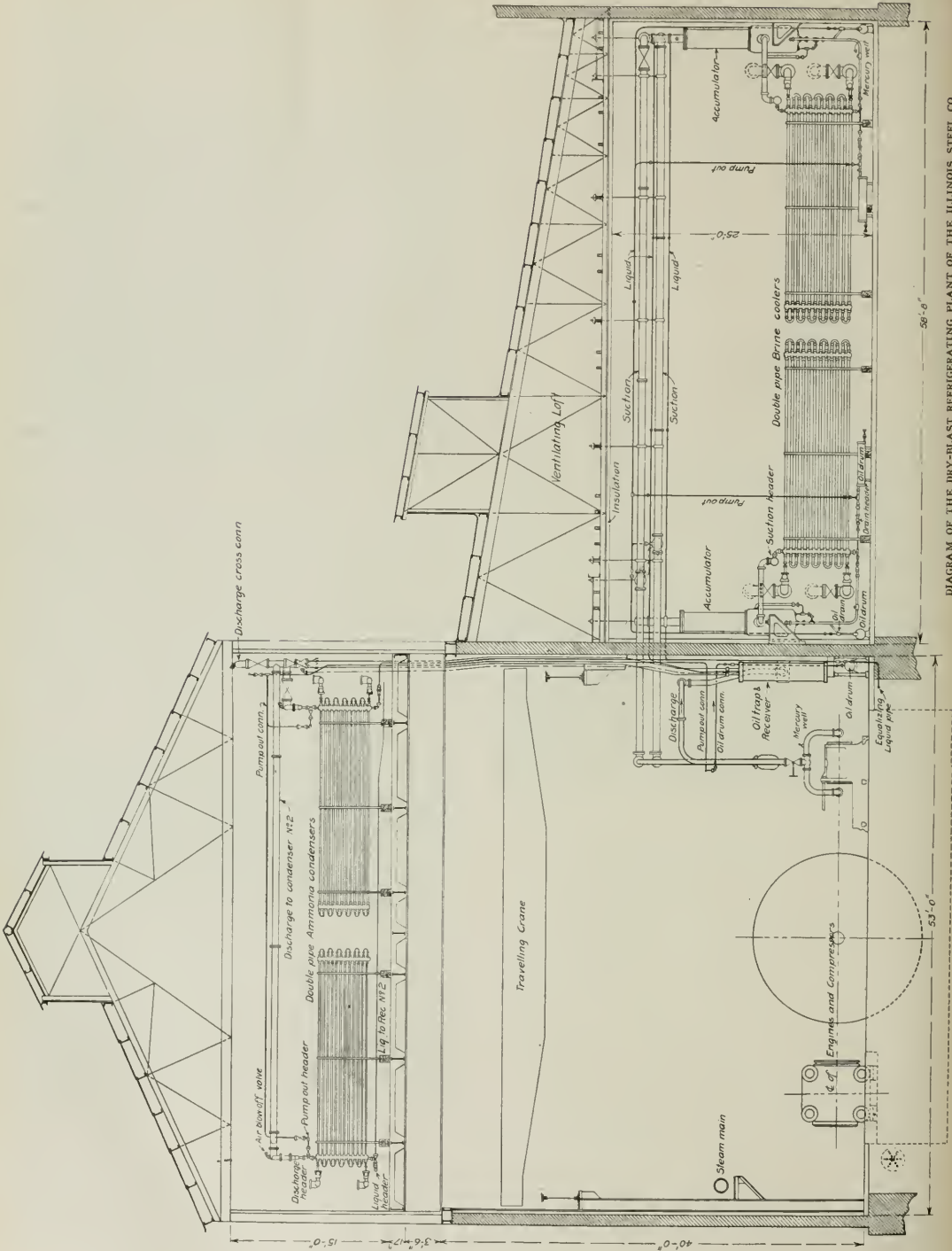


DIAGRAM OF THE DRY-BLAST REFRIGERATING PLANT OF THE ILLINOIS STEEL CO.

monia—the boiling point of which at the working pressure employed in the apparatus lies between 5 and 10 deg. Fahr.—is converted into steam or gas, which returns to the ammonia compressors to undergo again the process of liquid action.

The Method of Distributing Ammonia.—While the installation in its various parts barely presents any features which could not also be found in other modern applications of refrigerating machinery, it is the method in which the liquefied ammonia is handled and uniformly distributed to the great extent of the cooling apparatus which deserves special mention.

In usual refrigerating practice this is accomplished by needle valves or expansion cocks attached to the supply side of each stand of the cooling apparatus, and by which it is attempted to regulate the supply of the liquid refrigerant as it comes from the ammonia condensers so accurately that each stand receives its requisite amount of ammonia; that is to say, no more nor less than such an amount as can be converted into steam or gas by the heat transmitted to it from the entire heating surface of each stand, which is the aggregate area of the outer pipe surface of the 2-in. pipes of each cooler. Unless this condition is fulfilled there will be either a portion of the heating surface left ineffective for lack of liquid ammonia to which the heat can be transmitted, or more or less of the refrigerant will pass through the cooling apparatus in liquid state and return to the compressors, curtailing the capacity or efficiency of the latter.

As the refrigerating process is in principle nothing but a process of evaporation, where a fluid of very low boiling point (liquid anhydrous ammonia boiling at 29.6 below zero F.) is converted into steam by the heat transmitted to it from a fluid of a temperature higher than this boiling point, practically the same course is adopted in the refrigerating apparatus of the Illinois Steel Company's dry blast plant as that pursued in the universally known evaporating apparatus; namely, steam boiler practice.

How the Cooling Process Parallels Steam Boiler Practice.—The heat extracting (cooling) apparatus as built by The Vilter Mfg. Co. under its patent 894,285 of July 28, 1908, may be compared with any of the familiar types of horizontal water-tube boilers, in which a group of tubes is connected to front and rear water legs carrying a common steam drum in which the steam separates from the entrained water as follows: From an elevated receptacle called the accumulator, which is partly filled with liquid ammonia, the latter flows through a large pipe (the rear water leg of the boiler) communicating with the inlet ends of all double pipe coolers into the annular spaces (the tubes of the boiler) formed between the inner wall of the 3-in. pipes and the outer one of the 2-in. pipes passing through them. Here it is subjected to the effect of the heat transmitted through the walls of the 2-in. pipes by the circulating chloride of calcium solution (the fire and combustion gases of the boiler furnace) and converted into gas (steam). The gas and entrained liquid ascend and reach another large pipe header (the front water leg of the boiler) connecting all the outlet ends of the double pipe coolers through which they enter the accumulator (steam drum of the boiler).

In this drum the separation of gas and entrained liquid takes place, the gas passing out on top through the main suction line to the compressor for reliquefaction, the liquid returning from the lower end of the accumulator to the double-pipe coolers for renewed circuit.

It is evident that through the adoption of this method of introducing the liquid refrigerant into the evaporating apparatus only one supply valve is needed for each battery of 20 coolers or for all four batteries if it were not for the demanded division into four separate units in this case—in the same manner as a great many boilers may be supplied by one boiler feed pump. It is also evident that through this flow by gravity through a communicating pipe the liquid refrigerant is distrib-

uted to all coolers alike in such quantities as will not only suit the varying conditions of temperature of the circulating and heat transmitting fluid, but also insure the full use of the total evaporating surface of each cooler.

Making the Cooling Process Continuous.—To make the cooling process continuous, the ammonia gas generated in the coolers is returned to the accumulator after being reliquefied by means of compression and subsequent condensation. In doing so, however, one important feature upon which hinges the success of the entire procedure has to be observed. The process of liquefaction must necessarily be performed at the temperature of the cooling water which is available for the ammonia condensers. The liquefied ammonia returning from the condensers to the accumulator is therefore of much higher temperature and under much greater pressure than are maintained in the evaporating or cooling coils of the apparatus.

If the liquid refrigerant were liberated in this condition from the high pressure under which it is delivered from the condenser, its sensible heat at the high temperature corresponding to that pressure would be consumed at once in converting a part of such liquid into gas. This partial conversion into gas of every particle of the fluid would be an instantaneous, flash-like one and would not only cause the loss for effective refrigeration in the cooling coils of this portion of the fluid, but also a disintegration of the compact flow of the liquid in the same manner as if water is blown from the test cocks of the water column of a boiler under high steam pressure or as it emanates from the blow-off pipe. This spray of liquid would be carried along with the current of gas flowing from the accumulator to the compressors, and, becoming unavailable for evaporation in the coolers, constitute a much greater loss in efficiency than the one alluded to heretofore.

To prevent this loss it is necessary to deprive the liquid refrigerant of its excess of sensible heat before it is relieved of its high pressure and admitted into the accumulator. This is accomplished by the use of a long spiral coil suspended in the upper part of the accumulator and exposed to the current of the cold gas flowing to the compressors through which the liquefied ammonia passes before it reaches the relief valve which supplies each battery of coolers.

The machinery installation was commenced the middle of March this year, and was completed May 5. It proved successful from the beginning and has been operated throughout the summer, exceeding in its performance by far the guarantees to which the builders, The Vilter Mfg. Co., had submitted in their contract with the Illinois Steel Company.

Condensing of Nitric Acid.

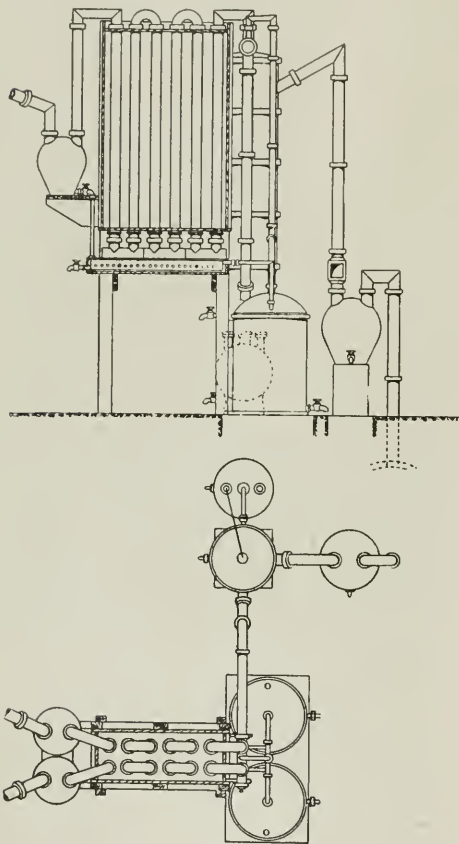
In the following we give a description of the latest form of condensing battery for nitric acid, invented by Mr. Oscar Guttman, and made by the Didier-March Co., of New York City. The large new works of this company in Keasby, N. J., where chemical stoneware, apparatus and appliances are made for all purposes of the chemical and metallurgical industries, were described in our last issue.

The operation of Guttman's new condensing battery for nitric acid is as follows: The gases on issuing from the still are rapidly condensed in a receiver and six long, water-cooled stoneware pipes with thin walls at such a temperature that a minimum amount of water contained in the gases is separated while the nitrous acid and chlorine remain in the gaseous state. These gases pass through the battery to the absorption tower, the temperature in which is so regulated that the chlorine and part of the water are driven off. The nitrous acid, however, is almost completely oxidized to nitric acid in its passage through the battery to the tower by a current of air which is simultaneously injected.

In order to obtain these results it is necessary that after condensation the nitric acid is rapidly removed from contact with

the uncondensed gases. For this purpose drain pipes are attached to the lower ends of the connecting elements, leaving a free passage for the gases. The drain pipes dip into the acid, which collects in a tubular cooling channel before running into the storage vessel; any gases evolved in this being conducted to the tower.

If it be desired to thoroughly "bleach" the acid, a little compressed air, which has been heated by an iron coil placed in the flue of the still, is blown into the storage vessel. When bleaching in this way the cooling water in the cooling channel has to be so regulated so as to be at a temperature of at least 50° C. on leaving the cooler.



NITRIC ACID CONDENSING PLANT.

A battery of six pipes can readily condense the distillate obtained from a charge of 2000 lb. The whole of the acid produced is of one strength only, so that no further blending is necessary. The acid when collected in the storage vessel is at such a temperature as not to irritate the workmen while drawing it off.

Guttman's condensing battery may be used for the manufacture of nitric acid of any desired strength by charging the tower acid again into the still and recovering it as strong acid at the next distillation.

The acid produced with Guttman's battery is nearly chemically pure; it is free from chlorine and sulphuric acid, and only contains small quantities of nitrous acid. Nitric acid of 96½

per cent (specific gravity 1.507 = 48.4° Beaume) contains about 1 per cent of HNO₂; acid of 1.420 specific gravity (42.7° Beaume) only contains traces.

The usual charge for a still is 2000 lb. of 96 per cent nitre. For the production of highest-grade nitric acid, 2420 lb. of sulphuric acid containing 94½ per cent monohydrate (1.838 specific gravity) are required; for the production of nitric acid of 1.420 specific gravity (42.7° Beaume), 2536 lb. of sulphuric acid of 79.36 per cent, or 1.725 specific gravity, are required.

Waste acid, such as that from the manufacture of gun cotton, may be used, and the nitric acid contained therein recovered as strong acid. The yield is in every case between 99 and 99½ per cent of that theoretically possible without the production of any weak acid of inferior value.

The coal consumption is 250 lb. per charge of 2000 lb. of nitre. The distillation takes about 10 to 11 hours; charging, emptying and drawing off require another two hours. The quantity of compressed air required for bleaching is about 100 cu. ft. at 45-lb. pressure per charge, and the consumption of water is 450 to 650 gal. Three men can easily work eight stills, two men four stills, while one man and an occasional helper are required for two stills.

With Guttman's battery one can, of course, distil weak nitric acid by mixing it with sulphuric acid of 1.840 specific gravity and distilling in suitable stills. A uniform acid containing 96 per cent nitric acid can hardly be obtained when distilling in cylinders as too much cooling takes place at the ends, and stills are required which are surrounded on all sides by the flue gases. A good absorption tower, like a Guttman ball tower, is another condition; one of 2 ft. 4 in. diameter is sufficient for four stills of 2000 lb. each. The cost of repairs are trifling.

Guttman's batteries are usually made in double sets, as shown in Fig. 1, so that twice six pipes are mounted in one water tank. If the tower attached to such a double battery is 2 ft. 4 in. in diameter and 10 ft. high, a second double battery may be connected to it.

The following table gives some figures concerning the charges and yields:

Manufacture of Nitric Acid from	Charge	Yield	Coal Consumption	Wages	Space Occupied
Nitre and strong sulphuric acid.	2,000 lb. of 96% NaNO ₃ , 2,420 lb. of 94.5% H ₂ SO ₄	1,644 lb. HNO ₃ of sp. g. 1.504, i.e., 99% of the theoretical.			
Nitre and weak H ₂ SO ₄	2,000 lb. of 97% NaNO ₃ , 2,536 lb. of 79.36% H ₂ SO ₄	2,397 lb. HNO ₃ of sp. g. 1.420, i.e., 99.4% of the theoretical.			
Nitre and waste sulphuric acid. (Yearly average of a government factory.)	2,000 lb. of 96% NaNO ₃ , 585 lb. of 96% H ₂ SO ₄ , Waste acid containing— 10% HNO ₃ 80% H ₂ SO ₄ 10% H ₂ O	1,854 lb. HNO ₃ of sp. g. 1.506 = 96.5% of the theoretical. 2,052 lb.	2½ cwt. per 20 cwt. of nitre.	3 men for 8 stills.	About 65 sq. ft. for two batteries, depending on the arrangement.

Girod Steel Process.

In connection with the description of the Girod electric steel furnace in our October issue (page 428) it is interesting to note that this furnace has recently been adopted by the following concerns:

Ste. An. John Cockerill, Seraing, Belgium, who have taken out a license for the installation of a three-ton furnace, to be worked in conjunction with their Martin or Bessemer steel furnaces for the making of structural steels.

Ternitzer Stahlwerke, von Schoeller & Company, in Ternitz, Austria, who are likewise installing a two-ton furnace on the Girod system to replace their crucible steel plant.

Oehler & Co., in Aarau, Switzerland, and Storz & Co., in Stuttgart, Germany, who are each fitting up a two-ton furnace, intended solely for the manufacture of steel castings. The

plant of Oehler & Co. was described in our November issue, page 452.

The Girod furnace has been used in the past at the works of the Société Anonyme Electrometallurgique, Procédés Paul Girod, Ugine, Savoy, France, for the manufacture of various special steels, not only carbon steels, but alloy steels. It is thought that the Girod furnace "is particularly adapted to the manufacture of case-hardening steels, owing to the fact that the action of the air is avoided, and that a sound non-oxidized metal can be cast without having recourse to excessive additions of manganese and silicon. After case-hardening, therefore, the central part remains highly fibrous, and the very hard surface has no tendency to splinter. Thus, an impression with the Brunel ball, 10 mm in diameter, with a pressure of 3000 kg, shows no cracks on the edges."

Some interesting notes on steels which have been made commercially in the Girod furnace, with the result of tensile tests, are given in a pamphlet recently issued by the representatives of the Girod process in this country, C. W. Leavitt & Co., 220 Broadway, New York City.

List of Heroult Furnaces.

The list of European Héroult furnaces, reproduced on page 469 of our last issue from *Stahl und Eisen*, is somewhat incomplete. We herewith give a corrected complete list, comprising both European and American Héroult furnaces:

	Finished, kilograms.	Under construction, kilograms.
1. Stahlwerke Richard Lindenberg, Remscheid-Hasten, Germany	3,000	....
2. Stahlwerke Richard Lindenberg, Remscheid-Hasten, Germany	1,800	....
3. Stahlwerke Richard Lindenberg, Remscheid-Hasten, Germany	500	....
4. Bismarckhütte, Bismarckhütte, Upper Silesia, Germany	3,000	....
5. Bismarckhütte, Bismarckhütte, Upper Silesia, Germany	1,000	....
6. Bismarckhütte, Bismarckhütte, Upper Silesia, Germany	*	*
7. Deutsche Mannesmann-Röhren Werke, Saarbrücken, Germany	*	*
8. Kaerthner Eisen & Stahl Werke, Austria	*	*
9. Deutsch-Oesterreichische Mannesmann-Röhren Werke, Burbeck	3,000	....
10. Danner & Co., Judenburg, Austria	2,000	....
11. Gebr. Böhler & Cie., A. G., Kapfenberg, Austria	2,500	....
12. Gebr. Böhler & Cie., A. G., Kapfenberg, Austria	*	*
13. Georg Fischer, Schaffhausen, Switzerland	1,000	....
14. Georg Fischer, Schaffhausen, Switzerland	5,000	....
15. Georg Fischer, Schaffhausen, Switzerland	5,000	....
16. Soc. Electromet. Française, La Paz, Savoy	3,000	....
17. Acieries du Saut du Tarn, St. Jurey, France	5,000	....
18. Aktiebolaget Héroults Elektriska Stål, Korffors, Sweden	4,500	....
19. Halcomb & Co., Syracuse, N. Y., U. S. A.	5,000	....
20. The Firth-Sterling Steel Co., McKeesport, Pa., U. S. A.	3,000	....
21. Società Tubi Mannesmann, Dalmine, Italy	6,000	....
22. Società Tubi Mannesmann, Dalmine, Italy	6,000	....
23. Edgar Allen & Co., Sheffield, England	3,000	....
24. Edgar Allen & Co., Sheffield, England	*	*
Total	35,300*	28,000

*Size and number not yet determined.

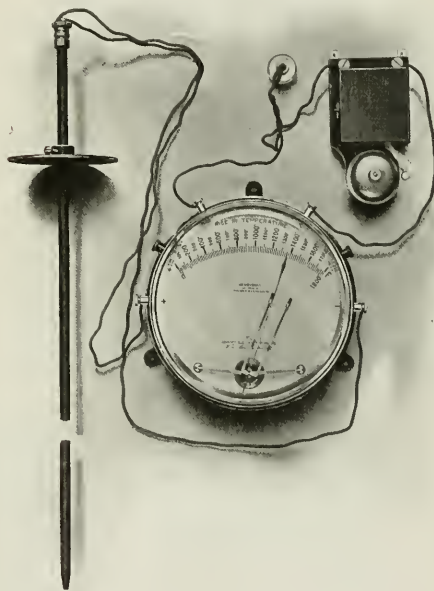
No. 6, contemplated by Bismarckhütte, will be a large furnace, but the exact size has not yet been fixed. The Austrian Mannesmann Co. is building a 3,000-kg furnace (No. 9); the size of the furnace to be erected by the German sister concern (No. 7) has not yet been determined; two 6,000-kg furnaces are under construction by the Italian Mannesmann Co.; size of No. 12, to be erected by Gebr. Böhler, has not yet been determined.

The Alarm Pyrometer.

The accompanying illustration shows the latest form of the Advance electric pyrometer, the purpose of which is to give an alarm when the temperature of the furnace to which the apparatus is applied falls out of the desired range of temperature within which it is intended that the furnace be operated.

It serves a purpose that a simple indicating instrument or a recording instrument cannot exactly accomplish. In a great deal of work there is not only one temperature that is desired, or at least that it is possible to continuously maintain, but there are certain upper and lower limits between which the work should be done and this alarm pyrometer gives timely notice when either of those limits is being approached. It, therefore, is not only a check upon the furnace man in the sense of being a tell-tale if his temperatures vary too greatly, but it is a genuine aid to him in that it calls his attention to the improper tendency of the temperature of the furnace in time to rectify matters.

Little need be said as to the operation of the pyrometer, for it is simply a thermoelectric pyrometer, but it should be pointed out that the electric current from the fire-rod (thermocouple) is wholly independent from the electric current that operates the alarm bell. The latter is supplied from batteries or house circuit, which passes through the indicating hand of the gauge and through whichever of the contact fingers that indicating hand may touch.



ALARM PYROMETER.

Good electric contact is insured by the two iridium points on the indicating hand and the two carbon tips on the fingers. The position of the two alarm fingers may be instantly adjusted and, of course, when the indicating hand moves within the limits set by them and not touching either, the bell is not sounded, but instantly upon contact with one or other fingers, notice is given by the alarm bell that attention to the furnace temperature is required. By throwing the alarm fingers, one or both, outside of the range of the instrument, the pyrometer becomes an alarm instrument for one instrument only or a simple indicator. Good electrical contact is insured between the indicating hand and the alarm fingers, as the bell works on 110 volts.

This alarm pyrometer is the principal feature of the new complete pyrometer catalog just issued by the Wilson-Maculeu Co., of 1 East Forty-second Street, New York City.

Plating Rheostats.

The Ward Leonard Electric Co., of Bronxville, N. Y., have designed a complete line of plating rheostats, both for field and line control. Fig. 1 shows the "field rheostat" with special circuit-breaker. If an article is to receive a plating of certain weight, it is suspended on a balanced beam in the plating tank. When the weight has been deposited, the beam falls, the circuit-breaker operates, and the circuit is broken.



FIG. 2.—LINE RHEOSTAT.

Fig. 2 shows the "line-control rheostat." This is a unique and new design for this apparatus and offers great possibilities. It is designed for single-voltage and double-voltage control.

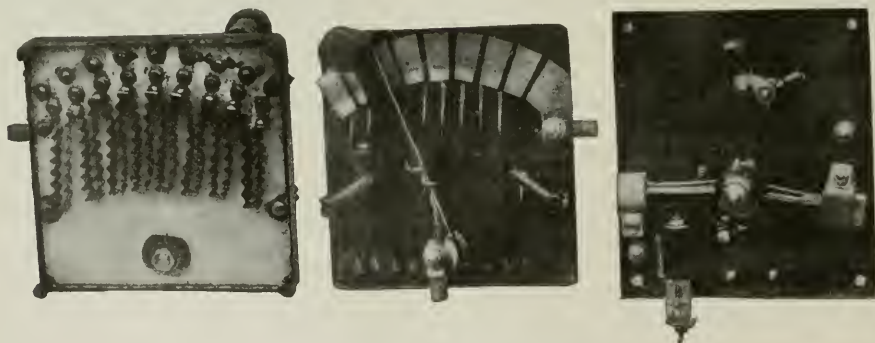


FIG. 1.—BACK AND FRONT VIEWS OF FIELD RHEOSTAT WITH CIRCUIT-BREAKER.

The illustration shows a double-voltage type to be used on a 5- and 10-volt circuit, i. e., either on one leg of a three-wire circuit having 5 volts on each leg, or upon the total 10 volts. There is a plain line switch (fused when so desired), which closed in one direction gives any amperes from 1 to 40 amp on 10 volts, and when closed in the opposite direction gives 80 amp on 5 volts. This gives 31 steps of control on either voltage. Each switch, with its resistance, is designed to be connected across the full 5 or 10 volts, respectively. The various numbers of steps are obtained by using the switches singly or in parallel. As the resistances are designed for the maximum

voltage that can be applied upon them, "burn-outs" are impossible. These rheostats are designed for any capacities and voltages.

Concentration.

While, in general, for the concentration of crushed ore a series of operations is required which are carried out in different machinery adapted for "preliminary separation" and for "final separation," respectively, the object of the Woodbury system of concentration is to eliminate largely preliminary separation by means of classifiers, screens, etc., and to combine into one the classifying and jiggling operations.

The concentration is carried out in a series of jigs, of which the first is the feature of the system, being a combined slime classifier and jig. It treats an unclassified or mixed feed, not coarser than three-eighths of an inch, and including slimes, performing the regular functions of a jig by making a clean cup and hutch concentrate and at the same time effecting an absolute separation of slimes from the jiggling material, with little or no dilution of the slimes.

This classifying jig is shown in Fig. 1. It is built with a plunger compartment at the head of the machine, in which a plunger is actuated by means of eccentrics. A differential motion of the eccentrics results in a quick downward and slow upward motion of the plunger. The charge is delivered at the head of the machine and flows over a sieve of suitable mesh, supported on sieve bars. The action of the plunger imparts a differential pulsation to the water up through the sieve bars. The pulp flowing over the sieve is lifted sharply by the pulsation and allowed to descend naturally, or, in other words, by gravity, resulting in its thorough stratification, heavy mineral settling to the bottom, then middlings, sands and slimes. There are four discharges from the classifier: the slime 2, approximately 60-mesh and finer; the tail product 3, which is usually re-treated on the following jigs; the coarse cup concentrates 4; and the fine or hutch concentrates 5.

The slime-classifying device consists of a large brass shield, adjustable vertically, and so set that the pulp on the sieve ef-

fectually seals it against the entrance of slimes. The pulp falling onto the sieve is subjected to the jiggling action, the light particles or slimes being scrubbed out of the gravels and sands and held in suspension by the hutch water from below. The suspended matter, or slime, is carried around this shield, over the tailboard and away for further treatment. By regulating the height of the tailboard, the mesh of the particles, separated as slimes, can to some extent be governed.

The pulp moving on the sieve bed is drawn along inside the shield toward an opening or slot, somewhat lower than the slime discharge. This opening is controlled by a gate and is

regulated to suit the quantity of feed to be treated. The height of this opening regulates the depth of the sieve bed, and is determined once for all time. The discharge of the pulp from the slot, having been subjected to the jiggling action, constitutes a retreating middling, which is usually cleaned up on the subsequent jigs.

Another brass shield inside the large slime shield constitutes a cup for the drawing off of coarse concentrates. This cup extends down and into the bed of concentrates, and discharges the same through a pipe and away from the machine. From the hutch plugs of the classifier is drawn a large volume of clean, fine concentrates, which have jiggled through the sieve bed into the hutch.

The body of the machine is built of cast iron, being a one-piece casting, strong and substantial, with all discharges conveniently located. Double eccentrics are fastened to shaft and are graduated for ready adjustment to different strokes; bearings are babbitted, and have ample oiling facilities. The quick

bed, which seals it against the entrance of low-grade material. Concentrates are discharged from the cup by an adjustable brass discharge, the height of which controls the depth of concentrate bed on sieve, which in turn controls the quality of hutch product discharged by means of plugs.

The middling jigs are equipped with an efficient device for discharging middlings, viz., the hydraulic middling discharge. An angle iron shield is fastened across the tail of the jig, extending down into the middling strata, which seals it against the entrance of tailings. From under the shield a number of openings, placed at intervals of 6 in., lead into a hydraulic compartment. A fresh water supply therein, regulates the quantity and quality of middlings discharged from under shield through these openings, into this compartment, and out through plugs, in the bottom. The tailings from one jig pass over angle-iron shields and hydraulic compartment to water lessener of next succeeding jig. The advantages of this device are a uniform discharge over the entire width of the jig and the separating of a true middling by holding back the light mineral and tailings with hydraulic water.

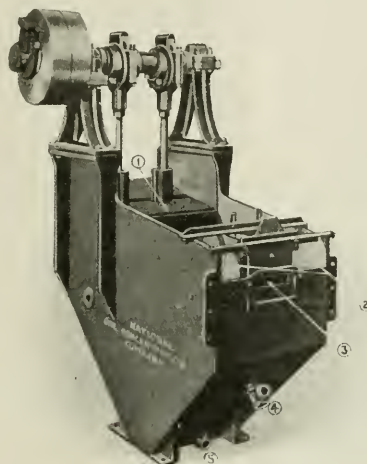


FIG. 1.—CLASSIFYING JIG.

return motion consists of a variable crank connection, between driving pulley and shaft; all wearing parts are of brass and can be taken up for wear as necessary.

As already mentioned the slime-classifying jig is usually followed by one or more compartments of Woodbury jigs to complete the separation of "concentrates," "middlings" and "tailings" as required.

The Woodbury jig is constructed with plunger compartment at head of jig. The feed flows on at head end and over the plunger compartment. The pulsations produced by the plunger are in line with the flow of pulp, instead of at right angles, resulting in an absolutely uniform pulsation the entire width of sieve and making an excellent stratification.

An important feature of the jig is the water lessener, a device for diverting the excess water of the feed into the hutch of the next succeeding jig. The pulp flows into a compartment from which it is discharged through plugs, over plunger compartment and on to the next sieve. The surplus water flows over top of lessener into a trough, communicating with the hutch under plunger, thus effecting a very material saving in hutch water as well as reducing quantity of top water, which otherwise accumulates and tends to carry off light values.

The discharge of concentrates from the sieve is accomplished by means of brass cups, which are located near the tail of the jig, and so placed that they will draw on bed of the concentrates equally from both sides. The cup extends into the concentrate

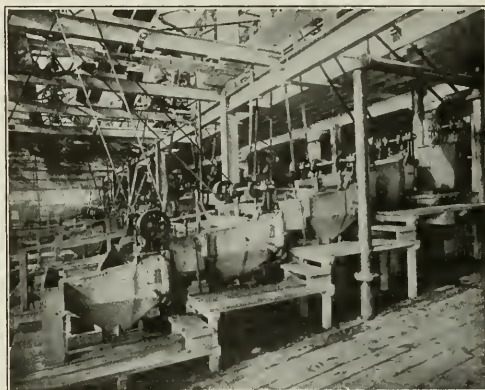


FIG. 2.—CLASSIFYING JIGS AT CALUMET AND HECLA PLANT.

Fig. 2 shows an installation of the Woodbury slime classifier and jigs at the Calumet and Hecla Mining Company's plant at Lake Linden, Mich. At these mills 28 sections are now equipped with the Woodbury machines and six years of continuous service have thoroughly demonstrated their economic value. In these mills a 3/16-in. feed, including slimes, is treated, the slime classifier separating the slime so dense that it goes direct to tables for treatment without being thickened. High-grade concentrates are made and the values lost in tailings have been very materially reduced.

The Woodbury jig is built by the National Ore Concentration Company, 1730 First National Bank Building, Chicago, Ill.

Electric Time Recorder.

Bristol's new electric time recorder (Fig. 1) was designed to meet the widespread demand for a simple and practical instrument to record automatically the occurrence and duration of various operations, such as the starting and stopping of machines, the opening and closing of valves, the duration of runs, etc. It may be used to advantage in connection with gas producers, Bessemer converters, for recording the charging and discharging of coke ovens, etc. With Bristol's electric time recorder it is possible to record several different operations on the same chart and the recorder may be located a long distance from the points at which such operations occur.

These new Bristol recorders have already been used in connection with machinery to show when the machines were started and stopped, how long they remained idle, and just when they were started again. Fig. 2 is a reduced cut of a record chart giving a complete 24-hour record of the operation of two paper machines. This record shows the time and duration of each break and also the time required to wash the felts and put on new wires.

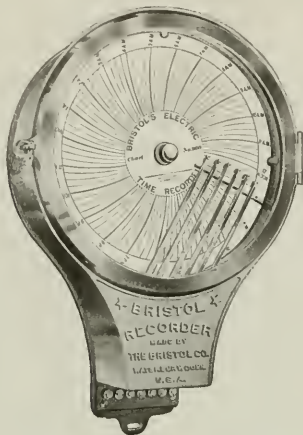


FIG. 1.—ELECTRIC TIME RECORDER.

One of these recorders arranged to record operations at six different points is shown in Fig. 1. Each one of the six pens shown on this instrument makes an independent record, continuously and automatically, and in this way six different opera-

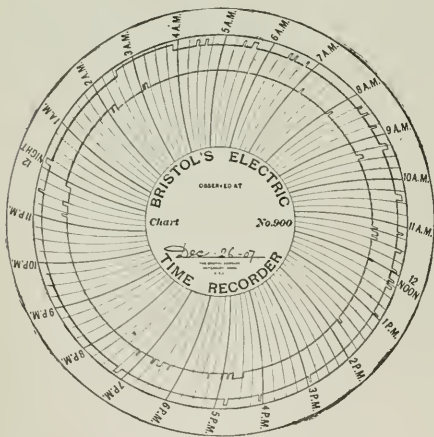


FIG. 2.—RECORD CHART.

tions may be recorded on the same chart. Each pen is actuated by an independent electromagnet and battery-circuit, so arranged that closing the circuit causes the pen to move a certain distance on the chart. Binding posts are provided at the base of the recorder, to which pairs of small lead wires are attached. These wires may be of almost any desired length, it only being necessary to have the object whose motion is to be recorded open or close the circuit whenever the motion occurs.

These recorders are usually operated by a battery circuit, but any convenient circuit may be employed by the insertion of lamps or other resistance to reduce the e.m.f. across each electromagnet. The object whose motion is to be recorded is caused to make and break this circuit through any convenient contact. The Bristol Co., Waterbury, Conn., are the manufacturers of these recorders.

Dry Concentrating Table.

A successful dry concentrating process has, in comparison with wet concentration, that evident and very important advantage that the concentrating mill can always be installed right next to the mine, so that the ore has not to be transported to some place where sufficient water is available. Naturally attempts to design a reliable dry concentrating table have been many.

In his suggestive and interesting presidential address of last year before the Western Association of Technical Chemists and Metallurgists, Mr. W. G. Swart made the following remarks concerning dry concentration:

"As to dry concentration of ore some facts have now been more clearly established than ever. First, dust cannot be concentrated and must be removed. Second, sizing must be very much closer than for wet concentration, which brings up the screening problem. Third, the active body of air must be divided up into small sections, since it is not practically possible to handle ores in large masses continuously, as, for example, on the Hartz jig. Finally, the dry mill has a labor problem of its own, since the ordinary millman does not understand clearly the underlying phenomena."

With respect to these requirements it is interesting to describe the Behrend dry concentrating table, made by the Behrend Dry Concentrator Company, 10 Wall Street, New York. Perhaps the most significant fact in connection with it is that the labor problem of the dry concentrating mill appears to be solved. As will be seen from the following description, the adoption of the air-suction or exhaust principle instead of air blast has resulted in such a simple construction that any ordinary millman or boy can adjust the table. It only requires eyesight, not any special skill or knowledge. Moreover, the exhaust principle makes the operation naturally dustless.

The accompanying illustration shows the construction of the Behrend table. The air enters at *A* and is forced to pass between the table, provided with riffles, and the top glass plate above. The air suction is produced by a fan, the driving axle of which is shown at *B*. In the latest design a sirocco fan has been adopted. The ore is fed through the hopper *C*, and by means of a continuous vibratory movement of the table (the driving axle of the mechanism being shown at *D*) the ore is moved down the table, while being thoroughly moved and agitated. The air current (moving in the direction opposite to that of the core) meets the ore. The heavier metal particles remain on the dressing table and pass down toward *A*, while the lighter gangue matter and dust are taken up and along with the air current.

There are two types of the Behrend table. In one the riffles on the dressing table are perforated and the lighter gangue and dust particles are carried together with the air downward through the riffle perforations. In the other type the riffles are not perforated and the lighter gangue particles and dust are carried along by the air current to a discharge at the back.

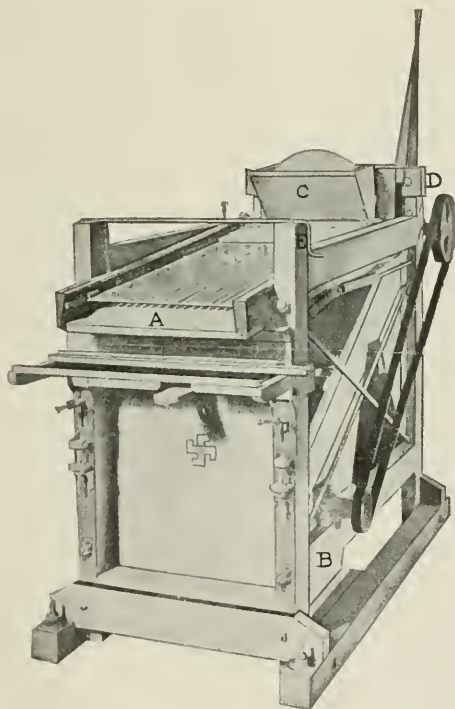
The heavier metal particles, therefore, pass out at *A*. The lighter gangue matter is taken by the air current down into the base of the concentrator onto baffle boards, and when sufficient weight has accumulated, an outlet valve opens and discharges the tailings. The dust is carried on through with the exhaust air into a special dust chamber, where it is collected.

The capacity of the standard Behrend table is from 8 to 15 tons in 24 hours, according to the sizes treated. The weight

of the concentrator is 500 lb. The floor space is $3\frac{1}{2}$ ft. x 6 ft. The power required is said to be now less than $\frac{1}{2}$ hp.

The table appears to be well designed. The width of the table seems to be just of the right dimension to enable thorough control of the air current. This control is, of course, also aided by the rifles.

The adjustment of the table is exceedingly simple. The amount of material charged through the hopper can, of course, be easily regulated. More important is the adjustment of the air current. Since the fan runs at constant speed, the regulation of the air current must depend on a regulation of the air supply, and this is accomplished by raising or lowering the top plate above the dressing table. This is done by a little wheel (only slightly indicated in the illustration). The operator, while turning the wheel, watches the discharge until his eyesight tells him that the discharge of concentrates is right. The table is then adjusted, once for all, as long as the charge does not vary; and it is clear that a boy should be able, with a little experi-



DRY CONCENTRATOR.

ence, to attend to a large series of dressing tables. The only important thing to look after is that the concentrates are discharged in clear condition and in proper volume.

The success of the concentrating tables depends, of course, on the proper condition of the charge. The ore must be fairly dry, crushed, pulverized and screened to correct sizes, according to the condition of each case. Mr. Samuel K. Behrend, the inventor of the concentrating mill, has therefore also designed a continuous ore drier and a pneumatic sizing screen, the latter being also operated on the exhaust principle.

As an example of the work of the Behrend concentrating table it is stated that when "working on a complex ore, favorable to concentration, containing 9 per cent lead, 12 per cent zinc, the remaining constituents being iron and silica, the result is 70

per cent lead concentrates, the iron carrying less than 1 per cent lead and about 3 per cent zinc, and the zinc product was brought up to 40 per cent."

A testing plant under the Behrend system is maintained by Messrs. Hy. E. Wood & Co., of Denver, Col. In New York City, Behrend testing tables are shown in operation at the Shippers' Exchange, Twenty-second Street and Eleventh Avenue.

Buying on Chemical Specifications.

Where dimensions, weight, finish and the like may be readily expressed in specifications, it is easy and natural to make them conditions upon which purchases shall be accepted. But where strength, chemical composition, durability and similar factors of ultimate efficiency are of importance, specification of these features is all too often omitted.

The reason is obvious; tests must be applied which usually call for equipment, knowledge and experience beyond those possessed by the average buyer. He is then obliged to turn to the expert, but objects because of the initial expense and fails to recognize the ultimate economy.

In every industry some material is being bought on the basis of brand, reputation or even satisfactory experience in its use without the least idea that equal efficiency might be obtained at a lower price with a suitable material whose composition could be specified in advance by the chemist. But where the purchaser is alive to all such savings they may be made to aggregate a considerable net amount after all expert service is paid for. The following experience is suggestive:

The purchasing agent of a large electric railway company was recently buying of a reputable supply house a metal for journal linings, which gave good satisfaction. He was paying 20 cents a pound, and, in view of the nature of the material, felt that the price was high. A sample was submitted to the Arthur D. Little Laboratory, in Boston, for analysis. Upon receipt of their report, the purchasing agent sent out for bids upon a metal of the composition shown on analysis. A reliable concern at once offered such a metal at 6 cents per pound. As the amount of metal used in a year was large, the saving by having the same metal made to their formula was well worth obtaining.

Notes.

The Chemists' Club of New York City has celebrated the tenth anniversary of its birth on Nov. 21 with a dinner in the lecture hall of the club.

Alcohol from Natural Gas.—The Continental Natural Gas Alcohol Co., of Wheeling, W. Va., has been formed to make installations for the manufacture of industrial (denatured) alcohol from natural gas, under the patent of Mr. Carl von Hatzfeld. We intend to describe the process in our next issue. It is stated that 5000 cu. ft. of natural gas will produce about 50 gal. of alcohol.

Tested Reagents.—We have received from Messrs. Merck & Co., of New York City, a copy of their "Prices and Uses of Tested Reagents—1909." Merck's reagents are submitted to the tests described in the well-known book, "Chemical Reagents, Their Purity and Tests," published by Van Nostrand Co. in 1907. Merck's tested reagents are indicated by a blue label, to distinguish them from Merck's photographic, medical and technical chemicals.

The Salt Lake Hardware Co. of Salt Lake City, jobbers of iron, steel, metals, mine and mill machinery, assayers' supplies, etc., are proceeding rapidly with the construction of their new warehouse, which is expected to be the finest warehouse in the entire intermountain country. They are also preparing their new hardware catalog, which will contain not less than 2000 pages, and which will be ready in Spring.

The Siemens & Halske Co. and the Siemens-Schuckert Co. of Germany, have opened American offices, with headquarters

at room 1559, Hudson Terminal Building, New York City, in charge of Dr. Carl G. Frank. Among the apparatus which they intend to push especially in this country are the well-known Siemens ozone apparatus for purification of water, further high-grade laboratory and switchboard instruments, Roentgen apparatus, induction coils, etc.

Grab Buckets and Tubs.—The Brown Hoisting Machinery Co., of Cleveland, have sent us their new bucket catalog. "Brownhoist" grab buckets, varying from 10 tons to $\frac{1}{2}$ ton in capacity, are used the world over for handling coal, ore, limestone, clay, cinders, sulphur, etc. The well-known two-rope buckets are illustrated in use on many different types of machines. The single-rope buckets for use on existing machines, having but a single-drum engine, are also described and illustrated. Automatic dumping tubs for handling coal, ore, stone, etc., are also described. The catalog is illustrated by many very fine and interesting illustrations.

Storage Batteries.—We have received from the Haschke Storage Battery Co., of 271 Michigan Avenue, Chicago, their catalog of the Haschke "fool-proof" storage battery. The plates are of thin cast lead, electrochemically formed. Each positive plate is encased in an envelope that perfectly insulates it. This insulating envelope, which is sufficiently porous to permit free circulation of the electrolyte and which is practically indestructible, is the main feature of the battery. The plates are "of such thickness as to withstand the strain of peroxidizing and at the same time to obviate the danger of buckling, while thin enough to materially reduce the weight of the cell, thereby making an accumulator capable of standing heavy charging and discharging without injury, and of quickly reviving itself." The battery is chiefly intended for ignition purposes, electric automobiles and yachts, for car lighting and for laboratory work.

Fused-Quartz Chemical Apparatus.—The Wilson-Maenlen Co., 1 East Forty-second Street, New York, have issued a very artistic catalog of quartz chemical apparatus. It may not be generally known that there are two kinds of fused quartz on the market, one transparent and the other only translucent. The transparent quartz is made from rock crystal SiO_2 , for laboratory sizes only; all surfaces are perfectly glassy (indeed, a transparent quartz tube has exactly the appearance of a glass tube); complex forms, such as retorts and distilling flasks, are made very symmetrical; fused-quartz apparatus are quite expensive. Translucent-quartz apparatus are much cheaper; they are also made from pure silica in large and small apparatus; in laboratory sizes both surfaces are smooth, large pieces have one smooth and one frosted side. The translucent quartz is sold in this country under the trade name "electroquartz." Both the transparent quartz and the electroquartz are not attacked by acids (except hydrofluoric), have a melting point above 2900°Fahr. , and such a small coefficient of expansion as to stand the most violent and sudden changes of temperature without cracking. Quartz has high electric insulating properties, even at high temperatures. Fused quartz apparatus may be used as a substitute for platinum and fine porcelain for many purposes in the laboratory and chemical factory.

Acetone.—According to the Cleveland *Leader*, Mr. K. P. McElroy, of Washington, D. C., has brought suit against the Kessler Co. and Mr. W. A. Harshaw, of Cleveland, for infringement of the patent for making acetone of Mr. H. O. Chute, consulting chemical engineer, of New York City.

Steel Rails from Cuban Iron Ore.—The Bethlehem Steel Co. is reported to make now steel rails containing 0.75 carbon and below 0.04 phosphorus and sulphur in their open-hearth furnaces, using pig iron from very pure iron ore of Cuban mines. These rails are said to be sold at quite an advanced price.

Repairing Iron and Steel.—A compound placed on the market by the H. W. Johns-Manville Co., of New York, under the name of "Leak-No," resembles powdered iron and when mixed with water and applied like putty to defects in iron or steel arti-

cles, the manufacturers claim that it metallizes and becomes a permanent part of the article to which it is applied. In color it very much resembles iron, when hard. It is stated to be applicable to mend cracks in oil, steam, gas, air, ammonia or water pipes and to stand pressure as well as heat.

Pyrometer Testing.—An excellent little pamphlet of 11 pages, which should be in the hands of all chemical and metallurgical engineers, has just been issued by the Bureau of Standards of Washington on pyrometer testing and heat measurements. It is Bureau Circular No. 7. It contains the regulations on pyrometer tests of the Bureau and a table of the fees charged by the Bureau for the tests. The pamphlet is, however, generally valuable for its concise statement of the chief points which must be remembered in the calibration and use of the various types of pyrometers.

Nickel Salts for Nickel Platers.—Messrs. Fuerst Bros. & Co., 2 and 4 Stone Street, New York, have sent us the following interesting analyses of English nickel salts, made by the Mond Nickel Co., Ltd., of which Fuerst Bros. & Co. are the American representatives. According to analyses of Messrs. Stillwell & Gladding their pure commercial double salt, nickel ammonium sulphate contains 15 per cent nickel, no arsenic, no insoluble matter, and only a trace of iron, while the single salt, nickel sulphate, contains 21.05 per cent nickel, no arsenic, and traces only of iron and insoluble matter. These salts are therefore of excellent quality for nickel plating purposes.

The Jewell Water Improvement Co., of 120 West Jackson Boulevard, Chicago, has just issued its exceedingly well-illustrated catalog No. 8 describing its water purification apparatus for all classes of work, from the smallest capacity for family use to types used in filtering water for the largest cities. Illustrations, with descriptive notes, are given of the various gas-operated and steam-operated Jewell stills, also of Jewell stone filters, pressure filters, gravity filters, and settling tanks. The largest filter plant in the world of the American system, with a capacity of 100,000,000 gallons per day, for the purification of the Ohio River water at Cincinnati, Ohio, is built and operated under the patents of Ira H. Jewell.

Thermit in the Foundry.—The Goldschmidt Thermit Co. has just issued an illustrated pamphlet, full of valuable information, on applications of thermit in foundry practice. The chief value of thermit in foundry works consists in the fact that the high reaction temperature of thermit ($5400^\circ \text{deg. F.}$) can be produced anywhere and without apparatus of any kind, to increase the temperature of iron and steel and facilitate the introduction of other refractory metals which it may be desired to alloy with the metal for special purposes. It provides the only means of poling metal in the ladle without reducing its temperature. Thermit is not used in the converter or cupola, but only after the metal is in the ladle, ingot or riser. The various applications of thermit for these purposes are then described. Then follows an illustrated report of Engineer A. Obholzer on the methods used to avoid piping in steel ingots as applied in the Hungarian Government steel foundries at Diosgyor. The pamphlet is concluded by short articles on nickel thermit as an addition to cast iron and on calcium silicide as a purifier for metals, particularly steel.

Chemical Industries of Germany.—According to a recent consular report the German Society for the Protection of the Interests of the Chemical Industry at its recent annual meeting reported that no serious effects had thus far resulted from the general business depression. The number of chemical factories in Germany increased from 8505 at the beginning of 1907 to 8618 at the end of the year. The number of employees increased from 195,000 to 207,000. Their wages advanced from \$49,266,000 to \$54,740,000. The stock companies, numbering 166, reported at the close of 1907 a total stock capital of \$125,806,800, reserves of \$41,316,800, and outstanding debts amounting to \$22,514,800. They paid in dividends the sum of \$19,444,600 on the entire capital. This is an increase of 0.38 on the rate for 1906. The profits vary greatly in

the different branches. The average rate of profit during 1907 for the entire industry was 10.73 per cent, an advance of 0.7 per cent over the rate for 1906. The outlook for a continuance of high profits is not considered as favorable, partly on account of recent tariff arrangements and partly on account of the requirements of the new British patent law. But the customs statistics of the German Empire for the first half of 1908 give a most satisfactory showing for the commerce in chemicals. In comparison with the same period of 1907, there is a slight lessening of imports and a more marked increase in exports. The total exports of chemicals in the first six months of 1908 were 1,170,714 metric tons (against 1,143,376 in 1907) and the total imports 792,776 tons (against 800,423 in 1907).

Electric Laboratory Apparatus.—We have received from Mr. C. H. Thordarson, 153 S. Jefferson Street, Chicago, his catalog No. 3, describing various electrical apparatus for demonstration purposes and for laboratory work. Among them are electromagnets, laboratory transformers, high-tension transformers, a rotary converter for laboratory use, an alternating-current regulator, Ruhmkorff spark coils, and X-ray coils. These apparatus are all specially designed to cover a wide range of experiments. Thus by operating a transformer in series with an alternating-current regulator, all static and high-potential experiments may be shown, including the operation of X-ray tubes and the production of ozone by the silent discharge. Some of the apparatus and appliances may be used for specially striking experiments. For instance, a ring on which an insulated coil is wound carries an incandescent lamp in its center; the system is so designed as to have a specific gravity slightly greater than water. If inserted in a water basin, it will, therefore, sink to the bottom. But when an alternating-current electromagnet coil is placed below the basin, alternating currents are induced in the coil in the water and manifest themselves in a double manner by lighting the lamp and by raising the coil so as to float on the water, due to magnetic repulsion.

Personal.

Mr. James Gayley, the distinguished inventor of the dry-blast process, has resigned as first vice-president of the United States Steel Corporation.

Prof. Joseph W. Richards, of Lehigh University, secretary of the American Electrochemical Society, after having arranged and attended the New York meeting of the society, sailed again for Europe and intends to visit Switzerland, Italy and Egypt. Dr. Richards will be back in this country by Feb. 1.

Mr. Albert Ladd Colby, consulting engineer, of New York City, has returned with his family from Europe, after over a year's absence, studying by-product coke ovens and recovery processes and testing American coal in different types of by-product ovens. Until he opens a new office in New York, his address will be care of Engineers' Club, New York City, or South Bethlehem, Pa.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

ELECTRIC FURNACES (Continued).

575,826, Jan. 26, 1897, J. A. Deuther, of Boston, Mass.

Arc type. Feed charge-mixture, e. g., lime and carbon, directly into a shifting arc. The lower electrode is a cylindrical block, set vertically in the brick bottom of the shallow-pot furnace. The upper electrode is a cylindrical pencil of somewhat smaller diameter, hung so as to vibrate as a pendulum, being pivotted on a vertically-adjustable support. One or more charge-feed boxes, having an apertured bottom, are arranged to reciprocate in guide-ways mounted on the upper electrode, being automatically moved as the electrode vibrates. The charges

drop into the arc alternately on opposite sides of the upper electrode as it vibrates.

575,829, Jan. 26, 1897, John Joyce, of Andover, and James A. Deuther, of Boston, Mass.

Arc type. Feeds the charge mixture, e. g., lime and carbon, directly into a shifting electric arc. The lower electrode is a vertical cylindrical block, arranged on a reciprocating truck. The upper electrode is a fixed cylindrical pencil of somewhat smaller diameter. The electrodes are surrounded by a low inclosing wall, the furnace chamber being open at the top. Two feed boxes with open bottoms are arranged to reciprocate in a guide-way mounted on top of the upper electrode. Mechanism is provided for reciprocating the lower electrode and for simultaneously shifting the feed boxes so as to deliver the charge alternately at opposite ends of the upper electrode and onto the upper end of the lower electrode.

577,317, Feb. 16, 1897, Francis Jarvis Patten, of New York, N. Y.

Resistance type. A plurality of vertical carbon-rod resistors are arranged in a circle within a circular furnace wall. The upper end of each resistor is connected through a switch to the positive terminal of a direct-current dynamo. The lower ends of all of the rods are embedded in the carbon floor of the furnace, which is connected to the other terminal of the dynamo. The space within the furnace chamber and around the rods is filled with a charge-mixture, e. g., for the production of calcium carbide. A large carbon pencil occupies the dead or relatively cool space at the center of the charge, its lower end being imbedded in the carbon furnace floor. A current of, say, 300 amp at 50 to 100 volts is passed by the switch successively through the several resistors, quickly bringing each to incandescence. The switch comprises a circular tub containing acidulated water, with carbon plates, respectively connected to the resistors, arranged on its inner wall. A centrally pivotted carbon slab, connected to the dynamo, rotates in opposition to the plates.

577,329, Feb. 16, 1897, Nicholas Slawianoff, of St. Petersburg, Russia.

Arc type. Melts and casts metal in the form of rods, e. g., iron or steel, pig iron or copper alloys. The rod forms one electrode of a self-regulating arc, the end of the rod continuously melting off and moderating the temperature of the arc. The mold to receive the molten metal may constitute the other electrode. If the mold is non-conducting, it may contain a carbon or metal electrode to start the arc, the melted metal in the mold thereafter acting as electrode. For casting pig iron, the electrode which is melted should be positive; if negative, the cast iron is hard and useless. The molds for pig iron and copper alloys consist of compressed coke; those for iron and steel of quartz sand and a binder. According to a modification, two rods may be simultaneously melted, each being carried by a magnetic regulator and arcing to the pool of metal. Or one of the rods may be submerged in the pool, the other arcing to it. When large rods are melted, small pieces of metal may be melted by throwing them into the pool. The process is useful for uniting two pieces of metal by casting molten metal into the space between them. Also for filling blowholes in pig iron and copper, cracks and sand-blows in steel articles, and vents in iron pieces. The process may be rendered continuous by screwing additional lengths onto the rod to be melted. To soften the melted cast iron an arc may be sprung from a carbon-rod anode to the molten iron, impregnating it with graphite. Or the molten iron and steel may be run through a carbon tube into a coke mold. Hard, white pig iron may be superficially softened by melting and carburizing its surface by the arc from a carbon anode.

577,370, Feb. 16, 1897, Francis Jarvis Patten, of New York, N. Y.

Arc type. Employs arcs which reciprocate laterally between the lower end of a vertical carbon plate and the upper surface of a horizontal carbon plate. Shows two furnaces. The first

has an inclined carbon bottom, above and perpendicular to which are several parallel carbon plates. The plates are connected to one terminal of an alternating-current dynamo; the hearth to the other terminal. An electromagnet is arranged to produce a magnetic field within the arcing region. As the current slowly alternates, the arcs travel back and forth along the lower ends of the plates. The second and preferred type of furnace is similar, except that the upper plate electrodes are connected to the positive terminal of a direct-current dynamo and the lower electrode to its negative terminal. The magnetic field is slowly reversed to reciprocate the arcs by a commutator containing a liquid and connected to the dynamo by a shunt circuit.

NEW BOOKS.

UNTECHNICAL ADDRESSES ON TECHNICAL SUBJECTS. By Ja. Douglas. 169 pages. Bound in cloth. Price, \$1. New York: John Wiley & Sons.

ELECTRIC FURNACES: THE PRODUCTION OF HEAT FROM ELECTRICAL ENERGY, AND THE CONSTRUCTION OF ELECTRIC FURNACES. By Wilhelm Borchers. Translated by H. G. Solomon. 233 pages. Bound in cloth. Price, \$2.50 net. New York: Longmans, Green & Co.

PRACTICAL METALLURGY: AN INTRODUCTORY COURSE FOR GENERAL STUDENTS. By B. T. Turner. 103 pages; illustrated. Price, \$1.25 net. Philadelphia: Lippincott.

MINERAL RESOURCES OF ALASKA. By Alfred H. Brooks and others. 299 pages. Office of Superintendent of Documents. Washington, D. C. (Department of the Interior, United States Geolog. Survey bull.).

A COLLEGE TEXT-BOOK OF CHEMISTRY. By Ira Remsen. 725 pages; illustrated. Price increased from \$2 to \$2.25. New York: Henry Holt & Co.

A TEXT-BOOK OF EXPERIMENTAL CHEMISTRY (WITH DESCRIPTIVE NOTES) FOR STUDENTS OF GENERAL INORGANIC CHEMISTRY. By Edwin Lee. 470 pages; 57 illustrations. Bound in cloth. Price, \$1.50. Philadelphia: P. Blakiston's Son & Co.

THE REFRIGERATING ENGINEER'S POCKET MANUAL. By Oswald Gueth. 160 pages. Bound in cloth. Price, \$1.50. New York: Oswald Gueth.

GAS AND FUEL ANALYSIS FOR ENGINEERS: A COMPEND FOR THOSE INTERESTED IN THE ECONOMICAL APPLICATION OF FUEL. By Hermann A. Gill. Fifth edition, revised. 124 pages. Bound in cloth. Price, \$1.25. New York: John Wiley & Sons.

CEMENT LABORATORY MANUAL: A MANUAL OF INSTRUCTIONS FOR THE USE OF STUDENTS IN CEMENT LABORATORY PRACTICE. By L. A. Waterbury. 129 pages; figures. Bound in cloth. Price, \$1.

HYDRAULIC TABLES AND MEMORANDA. By Herman Daniel Jerrett. 150 pages; diagrams. Bound in cloth. Price, \$1.50. San Francisco: Hicks-Judd Co.

STEAM POWER-PLANT ENGINEERING. By G. F. Gerhardt. 945 pages; figures. Bound in cloth. Price, \$6 net. New York: John Wiley & Sons.

THE MECHANICAL ENGINEERING OF STEAM POWER PLANTS. By Frederic Remsen Hutton. (Third edition, rewritten.) 166 pages. Bound in cloth. Price, \$5. New York: John Wiley & Sons.

DYNAM-ELECTRIC MACHINERY. By Francis Bacon Crocker. 238 pages. Bound in cloth. Price, \$1.50. Chicago: American School of Correspondence.

STORAGE BATTERIES, THEIR THEORY, CONSTRUCTION AND USE. By Arthur Eugene Watson. 153 pages; illustrated; diagrams. Bound in cloth. Price, \$1.50. Lynn, Mass.: Bubier Publishing Co.

LECTURE-NOTES ON THE THEORY OF ELECTRICAL MEASUREMENTS. By W. Arnold Anthony. 131 pages; figures. Bound in cloth. Price, \$1. New York: John Wiley & Sons.

THE STRENGTH OF CONCRETE BEAMS. By R. S. Humphrey. 59 pages. Office of Superintendent of Documents, Washington, D. C. (Dept. of the Interior, United States Geolog. Survey bull.).

PIPES AND TUBES. By Philip R. Bjorling. 244 pages; 191 illustrations. Bound in cloth. Price, \$1.25. New York: Macmillan Co.

PHYSICS FOR SECONDARY SCHOOLS. By C. F. Adams. 490 pages; illustrations, diagrams. Bound in cloth. Price, \$1.20. New York City: American Book Co.

PROGRESSIVE PROBLEMS IN PHYSICS. By Fred. R. Miller. 244 pages; tables. Bound in cloth. Price, 60 cents. Boston: Heath.

NOTES ON THERMODYNAMICS. By Wilson H. Spangler. (The derivation of the fundamental principles of thermodynamics and their application to numerical problems.) 82 pages. Bound in cloth. Price, \$1. New York: John Wiley & Sons.

AN ELEMENTARY TREATISE ON THE DIFFERENTIAL CALCULUS. By W. Woolsey Johnson. 201 pages; figures. Bound in cloth. Price, \$1.50. New York: John Wiley & Sons.

THE NIAGARA RIVER. By Archer Butler Hulbert. 332 pages, with maps and illustrations. Bound in cloth. Price, \$3.50 net, boxed. New York: Putnam.

BOOK REVIEW.

INTRODUCTION TO METALLOGRAPHY. By Dr. Paul Goerens, docent in physical metallurgy at the Institute of Technology of Aachen. Translated by Fred. Ibbotson, lecturer in metallurgy at the University, Sheffield. 214 pages, 158 illustrations. Price, \$2.50. New York: Longmans, Green & Co.

The original German edition appeared in 1896. We quote from the author's preface: "This little book proposes to introduce the learner to the somewhat unfamiliar phenomena of physical chemistry, so far as they need consideration for metallographical purposes, and to make it possible for him to obtain a glimpse of the methods of investigating metals and alloys." Since it is the only book of its kind and since it is a good book, especially for steel metallurgists, the translation into English is heartily to be recommended.

After a description of the methods of determining cooling curves in the first chapter, the second deals with "the physical mixture" (aqueous solutions, fused salts, alloys) and applications of the phase rule. Then follows a chapter on "practical microscopy of metals," with useful hints on the preparation of the section by grinding and polishing, development of the structure by etching, and directions for the use of the microscope and camera. (With respect to grinding, it is peculiar that carborundum does not seem to be known yet in Europe as a commercial article.)

The last chapter, and the most important of the book, deals with the special metallography of iron and its alloys. This chapter has been practically rewritten for the English edition and thus brought up to date by the author.

In the whole, the book is only an introductory treatise, but as such, we wish to repeat, it is good and valuable.

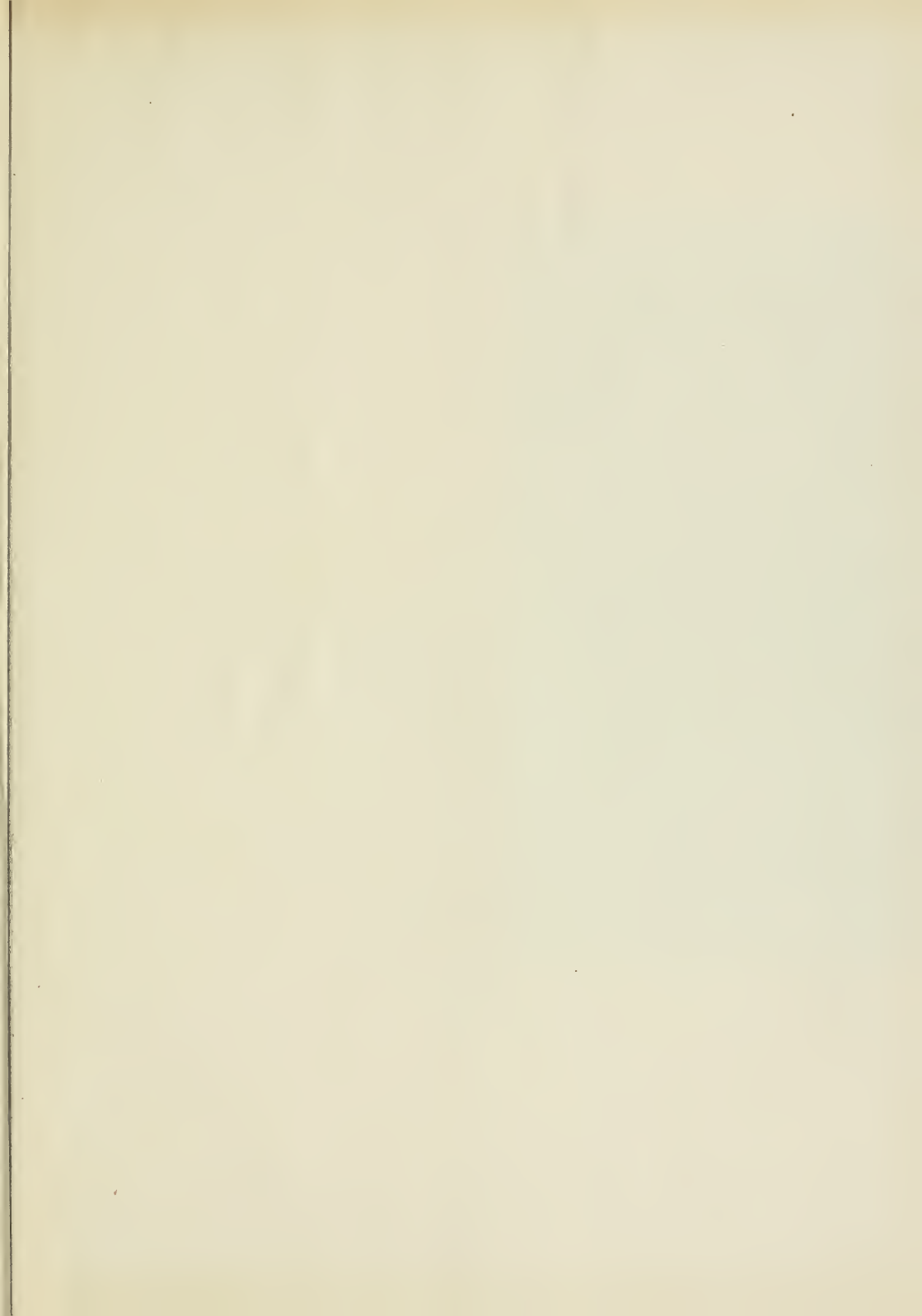
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MODERN PRACTICE IN MINING, VOL. I, COAL. By Prof. R. A. S. Redmayne. Price, \$2. New York: Longmans, Green & Co.

This is an admirable book. It is short and concise; yet it covers fairly thoroughly the occurrence of coal, the testing of its values, and the prospecting for it by means of modern drilling apparatus, such as the diamond drill.

Though written by an Englishman, we believe it will be useful to the American coal engineer, for it is a practical and well-written book. The author evidently knows his business.

No information is given on the ways and means of mining coal and getting it out, but it is to be presumed that this will be given in another volume.





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